FINAL REPORT

Demonstration of Energy Savings in Commercial Buildings for Tiered Trim and Respond Method in Resetting Static Pressure for VAV Systems

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Iowa Energy Center

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14. ABSTRACT
For existing buildings with variable air volume (VAV) system and direct digital control at the zone level, a modified version of the Trim and Respond method, the Tiered Trim and Respond (TTR) method, was implemented at five existing Iowa Army National Guard facilities to show energy savings compared to Fixed Pressure Control method. Comparisons were made by alternating static pressure control modes every two weeks between fixed static control and TTR control over a one year period at these facilities. Demonstration results showed that total fan energy savings for the five demonstration sites ranged from 14.4% to 34.8% compared with fixed static pressure control. Reduction in overall GHG emissions at five sites ranged from 0.6% to 4.7%. Simple payback years are 1.7, 4.9, 5, 11.8 and 14.9 years. Users (building occupants and facility engineers) mostly had no additional comfort complaints. The potential reduction in site energy across DoD installations could be 295 GWh per year, and the potential electricity cost savings could be 29.5 million per year.

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ACRONYMS AND ABBREVIATIONS

AASF	Army Aviation Support Facility
AFRC	Armed Forces Reserve Center
AHU	Air Handling Unit
ANSI	American National Standards Institute
ASA	Assistant Secretary of the Army
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
BACnet	Building Automation and Control Network
BLCC	Building Life-Cycle Cost
BRAC	Base Realignment and Closure
Btu	British thermal unit
CAV	Constant-Air-Volume
CEC	California Energy Commission
CO2	Carbon Dioxide
DDC	Direct Digital Control
DoD	Department of Defense
DOE	Department of Energy
eGRID	Emissions & Generation Resource Integrated Database
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
EUI	Energy Use Intensity
EW	Energy and Water
GHG	Greenhouse Gas
GSM	Global System for Mobile
GWh	Gigawatt hours
IAARNG	Iowa Army National Guard
IE&E	Installations, Energy & Environment
IESNA	Illuminating Engineering Society of North America
HVAC	Heating, Ventilation and Air Conditioning
JFHQ	Joint Forces Headquarters
LEED	Leadership in Energy & Environmental Design
MEPS	Military Entrance Processing Station
NIST	National Institute of Standards & Technology

OAT	Outside-Air Temperature
PI	Proportional-Integral (Control)
PID	Proportional-Integral-Derivative (Control)
RTU	Roof Top Unit
SIR	Saving to Investment Ratio
TR	Trim and Respond
TTR	Tiered Trim and Respond
USMEPCOM	United States Military Entrance Processing Command
VAV	Variable Air Volume
VFD	Variable Frequency Drive
WC	Water Column

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EXECUTIVE SUMMARY

Many existing DoD facilities nationwide operate their HVAC systems at design static pressure setpoint meant to alleviate building loads during hot summer or cold winter days. However, these design loads are not present the majority of the time. By optimizing static pressure rise in HVAC systems, significant fan energy savings can be achieved. Recognizing this, ASHRAE has moved forward in requiring the supply air static pressure setpoint be reset at the zone level in new buildings to satisfy the most critical zone. The reset can be accomplished through custom building control software programming, and the state-of-art algorithm is the trim and respond (TR) method. A modified version of the TR method, the tiered trim and respond (TTR) method, has shown promise in reducing air handling unit (AHU) fan energy use while maintaining steadier static pressure control in a lab study and a University campus building pilot study. For this demonstration, the TTR method was implemented at five existing Iowa Army National Guard facilities to show energy savings and control stability. Comparisons were made by alternating static pressure control modes every two weeks between fixed static control and TTR control over a one year period at these facilities.

Key benchmarks were used to determine the success of the project: fan energy savings of 30% or greater over fixed static pressure (FSP) strategies (based on past studies on the TR method), 6% reduction in overall GHG emissions, six months to one-year simple payback (based on a university campus building TTR pilot study,) and no additional user complaints.

Demonstration results showed that total fan energy savings for the five demonstration sites ranged from 14.4% to 34.8% compared with fixed static pressure control. Reduction in overall GHG emissions at five sites ranged from 0.6% to 4.7%. Simple payback years are 1.7, 4.9, 5, 11.8 and 14.9 years. Users (building occupants and facility engineers) mostly had no additional comfort complaints. The potential reduction in site energy across DoD installations could be 295 GWh per year, and the potential electricity cost savings could be $29.5 million per year.

Overall, the key energy savings results and user satisfactions met or partially met project objectives, while other targets such as system economics fell short of the original project goals. Contributing factors include low local electricity cost, non-ideal mechanical equipment and control operating conditions, and the need to hire control contractors to troubleshoot and solve “rogue zone” problems to make TTR method work effectively.

The factors influencing the energy savings and cost-effectiveness of building controls retrofit projects to convert fixed static pressure control to either TTR or TR method are summarized in the following table:

	Higher Energy and Cost Savings	Not Applicable or Lower Energy and Cost Savings
HVAC System Design	Forced-air variable-air-volume systems with DDC control at the zone level.	Force-air constant-air-volume system, radiant heating and cooling system, heat pump system, fan coil units, unit ventilators, and chilled beam systems are not applicable. VAV system control and radiant heating/cooling system control are not coordinated.
HVAC System Conditions	Well-maintained, commissioned, and operated as designed.	Not well-maintained, commissioned, or operated as designed.
Fan Power	Large AHU/RTU supply and return fans. The supply fan power is at least 3 horsepower at design condition.	Smaller AHU/RTU supply and return fans.
Controls Contractor	Reputable, reliable, and offers reasonable field service rate.	Unreliable and high field service rate.
Local Electricity Rate	Average aggregated electricity rate at least 10 cents per kWh.	Low aggregated electricity rate.
Facility Engineer	Is familiar with DDC systems and AHU/VAV control sequences. Can troubleshoot and fix common AHU/RTU and VAV mechanical and control problems.	Is not familiar with DDC systems and common AHU/VAV control sequences.
TTR Improvement	Add capability to ignore certain rogue zones on the TTR method specified.	Apply the TTR method as specified.
Retrofit Options	TTR/TR as one of the many control upgrade options in one retrofit project.	TTR/TR as the only control upgrade in retrofit.

1.0 INTRODUCTION

This document is the final technical report for the DoD ESTCP Energy and Water demonstration project titled "Demonstration of Energy Savings in Commercial Buildings for Tiered Trim and Respond Method in Resetting Static Pressure for VAV Systems." The goal of this project was to demonstrate the energy savings and control stability of a new method for controlling air handling units and rooftop units' fan speeds at five Iowa Army National Guard facilities. In this chapter, the background, drivers, and objectives for this demonstration project are described. Other details of the demonstration project are described in Chapters 2~8.

1.1 BACKGROUND

Based on the U.S Department of Energy (DOE) 2011 Building Energy Data Book [DOE, 2012], ventilation represents approximately 15.9% of a commercial building's overall building electricity use and 8.9% of total building energy use. Ventilation energy is mostly driven by air handling units' supply and return fans. The two most common HVAC system designs in commercial buildings are constant-air-volume (CAV) system and variable-air-volume (VAV) system. In a CAV system, air handling units' supply and return fans run at a constant speed, and the supply air temperatures vary to meet the building thermal load. In a VAV system, the supply and return fans' speeds vary to change the supply air flow rates while maintaining the supply air temperature constant. The VAV system gradually replaced the CAV system in building design because a VAV system is usually more energy efficient. However, in a VAV system, the fan sizing and the selection of static pressure setpoint is typically based on a peak load condition that usually only occurs several times a year, but the system runs at partial load conditions for a majority of the time. A system operating at a higher than necessary static pressure forces the fan motors to work harder resulting in wasted energy. Fan power can be significantly reduced if the static pressure setpoint can be reset based on real-time building/zone loads.

Since 1999, ASHRAE Standard 90.1 [ASHRAE, 2010] has required that static pressure setpoint be reset for systems with direct digital controls (DDC) at the zone level, and California Title 24 Building Energy Efficiency Standards [CEC, 2008] has a similar requirement. Various academic studies and empirical evidence have shown fan energy savings varies between 30% ~ 50% compared with the constant static pressure control strategy [Hartman, 1993] [Hydeman, 2003] [Taylor, 2007]. Many different methods implementing the static pressure reset strategy have been proposed, and some have been put into practice. A summary of static pressure reset methods in a flow chart format was illustrated by Kimla [Kilmla, 2009]. Non-demand-based methods include scheduling fans to a reduced fixed static pressure based on time of day [Federspiel, 2005], or based on outside air temperature [Liu, 1998] [Liu, 2000] [Zhu, 2001] [Turner, 2003] [Dong, 2005] [Evans, 2005] [Zheng, 2007] [Martinez, 2007] [Napper, 2007] [Zeig, 2007]. Wang proposed advanced genetic algorithms [Wang, 2008] but this is not yet practical at the current level of DDC system sophistication. In the past twenty years, three major types of demand-based pressure reset methods have been studied: 1) Airflow-based: Hartman [1989, 1993], Englander and Norford [1992], Warren and Norford [1993], Rose and Kopko [1994)], Liu [2002. 2008]; 2) Damper position-based: Haasl [2001], Song [2003], Pang [2006], and Nelson [2011]; and 3) Any indication of demand: Hartman [1995], Hydeman [2003], and Taylor [2007, 2015].

Airflow-based methods typically calculate the difference between the terminal units' airflow setpoints and measured values and then use the error signals to adjust supply fan speed. Another method determines the static pressure setpoint as a function of the AHU airflow rate. These airflow-based methods require measurements of terminal or AHU airflow which are typically not very accurate. The inherent inaccuracies and complexities make these airflow-based methods difficult to implement. Damper-based methods usually use the maximum of all zone damper positions as the indicator of overall system demand and control the supply fan speed in various ways. These methods are easier to implement because only the maximum damper position is used as the feedback signal. Furthermore, Kimla showed damper-based control methods save more energy than airflow-based control strategies based on results determined by theoretical simulation.

The static pressure reset strategy is still very under-utilized in many existing buildings with DDC controls, especially in commercial buildings with older generations of DDC systems. Many technical and economic reasons have contributed to the problem. Both methods have experienced problems with control instability and difficulty in tuning the system properly when applied to actual systems. Barriers to wider adoption of static pressure reset strategy also include limited or no programming/code modules readily available due to the proprietary nature of different programming languages used by DDC vendors. Consulting and facility engineers often fail to understand, emulate, and maintain this software implementation properly. Few case studies exist regarding the economic implications or analyses using this strategy in either new construction or retrofit projects.

Demonstrations and case studies focused on actual DoD buildings using different DDC systems highlighting the real economic benefits and providing programming examples will be extremely helpful in determining the practicality of implementing the control strategy as a retrofit solution in other existing DoD buildings which may have many different DDC systems. This demonstration project addresses the barriers and problems that have prevented the broader adoption of the reset strategy which could generate substantial energy savings and reduce building operation cost in tens of millions of dollars per year with very quick payback period.

- Current Technology State of the Art: Currently, the Trim and Respond (TR) method is the state-of-the-art approach in adjusting VAV system AHU static pressure setpoint and is part of the proposed ASHRAE Guideline 36 - High-Performance Sequences of Operation for HVAC Systems, which is still in public review. This method still requires careful tuning in the field and may experience control stability issues. In the 2011 ASHRAE Handbook on HVAC Applications, the pressure reset strategy is described in a simplified form - a variation of the TR method. In this method, a constant incremental (e.g., 5% of the design range) is recommended to be added (or deducted) to the current pressure setpoint when the maximum damper position is above or below a certain threshold (e.g., 98% and 90% respectively). Based on Nelson's study, the Tiered Trim and Respond (TTR) method is the "improved" version of the TR method and is used in this project to demonstrate the energy savings and control stability compared to existing AHU fan control strategies at DoD buildings. The detailed description of TTR method is presented in Chapter 2.
- Current State of Technology in DoD: Many of the existing DoD buildings are still using fixed static pressure control (no reset) for AHU supply fans. Several years ago, DDC system vendors started to provide static pressure reset control options for projects with new DDC systems (new construction or DDC system retrofit.)

Having multiple different DDC system providers complicates a systematic approach to implementing a standard best practice across all DoD buildings.

- Technology Opportunity: This technology addresses the barriers and problems that have prevented the broader adoption of the AHU static pressure reset strategy which could generate substantial energy savings and reduce building operation cost in tens of millions of dollars per year with a very quick payback period. It is estimated based on a prior pilot study that the simple payback period for the TTR method could be six months to one year. Reduction in site energy across DoD installations could be 549 GWh (Gigawatt hours) per year, which translates to facility operational cost savings of ~$49.4 million dollars per year while reducing CO2 emissions by 387,347 metric tons.

1.2 OBJECTIVE OF THE DEMONSTRATION

The main objective of this project was to demonstrate the control stability, ease of implementation and potential energy savings of the TTR method for different DoD building types. The second objective was to generate practical sample control programming codes under different DDC system platforms. These programming codes would then serve as “templates” for others (i.e., controls contractors, consulting engineers, facility engineers) to emulate and implement at additional future DoD sites. The third objective was to analyze the economic benefit and demonstrate the cost effectiveness of applying the proposed method to different DoD building types using a basic life-cycle cost analysis.

Demonstration of the TTR method for AHU static pressure reset is necessary to help DoD achieve energy security because it will promote the wider adoption of the static pressure reset strategy on air handling unit fan control for forced-air systems, which can result in significant energy savings with a short payback period.

- <u>Validate</u>: The TTR method was implemented at five Iowa Army National Guard buildings of different sizes, building types and functions, and building control systems. The official demonstration period was one year which spanned various weather conditions. During the project, the AHU fan control strategies were switched between existing control method (fixed or TR method) and the new TTR method once every two weeks. Performance and energy use comparisons of the new method to the existing method were made to validate the estimated energy savings goals. The cost and benefit of retrofitting using the new technology were also analyzed and documented to validate the simple payback and life-cycle cost analysis estimation.
- <u>Findings and Guidelines</u>: The demonstration results and insights learned will help influence industry guidelines and standards. The team members are heavily involved in ASHRAE and will be able to incorporate the results of this research into ASHRAE Standard 90.1 as well as California’s Title 24 Energy Code, as appropriate. The first DoD users are the five demonstration buildings of the Iowa Army National Guard. Upon completion of a successful demonstration, the method can be quickly implemented by other DoD buildings for retrofit by reviewing the final report and sample program codes and guidelines for implementing the technology.

- Technology Transfer: The TTR method is in the public domain. It can be applied to buildings with forced-air VAV system using DDC at the zone level. For retrofit applications, good candidates for TTR are Joint Forces Headquarters, medium or large offices, classrooms, auditoriums, reserve centers, and armories that have large AHU/RTU supply and return fans. The building's VAV systems should be well-maintained, commissioned, and operated as designed to make TTR effective. DoD facility engineers' familiarity with DDC system and common AHU/VAV control sequences, local utilities' electricity rate, and controls contractors' service quality and service rate are also significant factors in the economics of the TTR retrofit. This technical report including TTR sample program codes (in four different DDC systems' programming languages) and functional test form will be available to all DoD branches via ESTCP, and to the general public. This report will facilitate the transfer of the technology to other DoD installations and help controls manufacturers to improve their default static pressure control algorithms. Presentations about the preliminary results of this demonstration have been made by the team PI at the 2016 ASHRAE summer conference and a conference paper published.
- Acceptance: Successful demonstration of the proposed TTR method will justify retrofit projects implementing the new method. Detailed documentation including guideline and sample codes on five different DoD building types and DDC systems will increase acceptance of this technology within the DoD.

1.3 REGULATORY DRIVERS

Existing regulations, Executive Orders, DoD directives, industry standards or other drivers that the proposed technology addresses are listed below:

- Executive Order: EO 13693, Planning for Federal Sustainability in the Next Decade, March 2015;
- Legislative Mandates: Energy Independence and Security Act, 2007, Public Law 110-140;
- Legislative Mandates: Energy Policy Act 2005, Public Law 109-58;
- Federal Policy: Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings, December 2011;
- DoD Policy: Department of Defense Strategic Sustainability Performance Plan, FY 2011;
- Service Policy: Memorandum, ASA (IE&E), 28 Jan 2014, Subject: Army Directive 2014-02 (Net Zero Installations Policy);
- Service Policy: Memorandum, ASA (IE&E), 14 Jun 2013, Subject: Sustainable Design and Development Policy Update;
- Service Policy: Memorandum, ASA (IE&E), 24 Aug 2012, Subject: Energy Goal Attainment Responsibility Policy for Installations;
- Service Policy: Programmatic Environmental Assessment: Army Net Zero installations, Final July 2012;

- Service Policy: U.S. Army Energy and Water Campaign Plan for Installations, Dec. 2007;
- Service Policy: AR 420-1 Chapter 22, Army Energy and Water Management Program;
- Specifications: ANSI/ASHRAE/IESNA Standard 90.1-2012 (ASHRAE 90.1-2010 and ASHRAE 189.1), Energy Standards for Buildings (Except Low-Rise Residential Buildings), 2010;
- State of Iowa Executive Order 41: all agencies shall identify and implement energy efficiency measures and reduce energy consumption in all conditioned facilities owned by the State as provided for in Iowa Code Section 473.13A.

These drivers call for a reduction in building energy consumption and greenhouse gas emission reductions, which are the two primary goals of this demonstration project.

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2.0 TECHNOLOGY DESCRIPTION

In this chapter, an overview of the technology is given, and advantages and limitations of the technology are described.

2.1 TECHNOLOGY OVERVIEW

Description:

In older commercial buildings, HVAC systems are often forced-air, constant-air-volume (CAV) systems (Figure 1.) In such a system, supply and return fan airflow rates are manually set to meet the maximum airflow requirements for thermal load and ventilation. The supply air temperature is controlled at a setpoint to satisfy the zones with maximum load. Reheat coils on constant-volume terminal boxes are controlled by individual thermostats to adjust the zone temperatures.

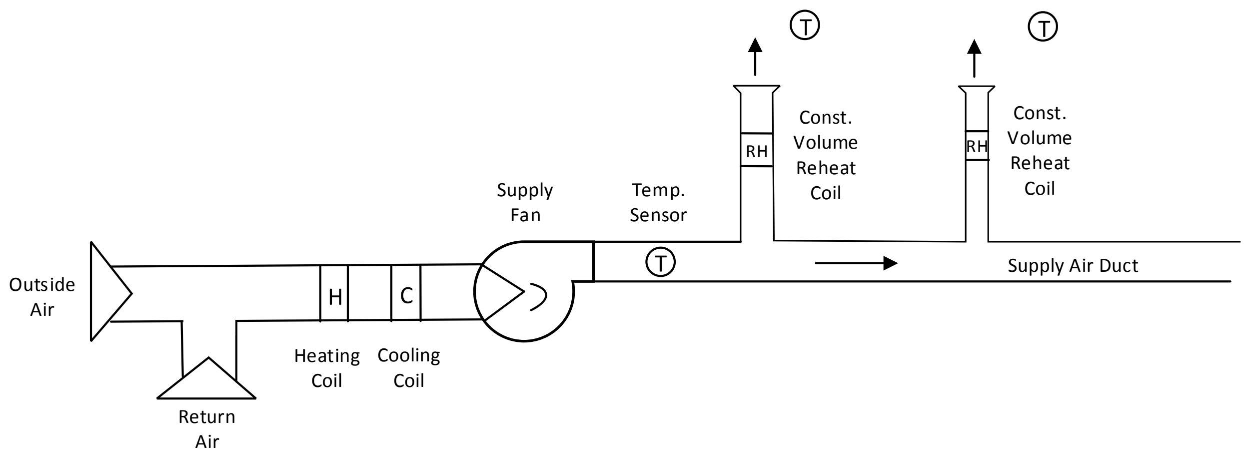

Figure 1. A Typical Single-duct CAV System Schematic

A different forced-air system design called variable-air-volume system gradually replaced constant-air-volume system because of VAV system is usually more energy efficient. A typical single-duct, multi-zone VAV system schematic is shown below (Figure 2) to highlight key relationships among components. In such a system, AHU supply and return fans are used to deliver air to zones through zone terminal units (or VAV boxes). AHU supply air is heated or cooled to maintain a certain temperature through heating or cooling coils. Terminal unit damper positions are continuously adjusted to provide appropriate air flow in each zone to meet the different cooling loads. AHU static pressure is usually maintained at a fixed setpoint based on peak load design conditions.

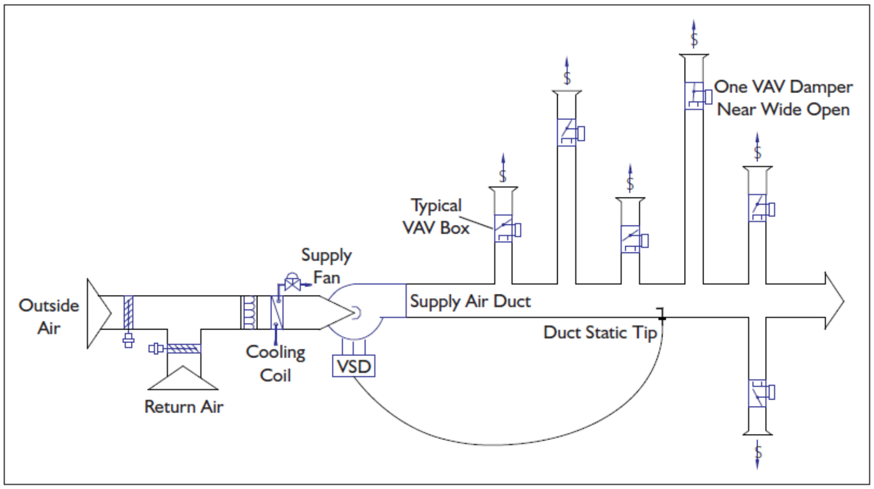

Figure 2. A Typical Single-duct VAV System Schematic

However, the majority of the time these HVAC systems do not operate at peak load conditions (Figure 3.) Automatically lowering AHU supply air static pressure at partial load conditions may significantly reduce fan energy used to deliver air to the system (Figure 4.) For example, point "B" in Figure 4 represents the supply fan operating point at 50% of the design air flow rate and fixed design static pressure of 1.5 inch WC. If the operating point can be moved to point "A" on the "ideal" static pressure curve while still maintaining 50% of the design air flow, the supply fan power can be reduced by approximately 57% (~12% vs. ~28% of design fan power when running at 100% air flow rate condition.)

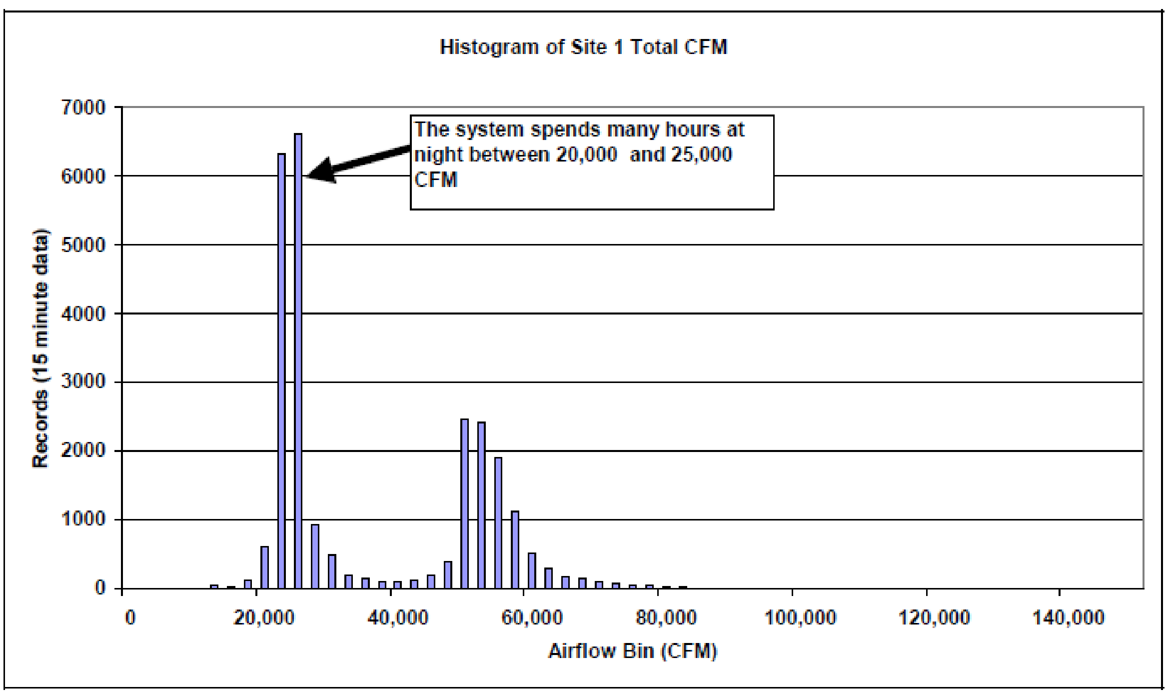

Figure 3. A Sample Histogram of Total Air Flow at a Site

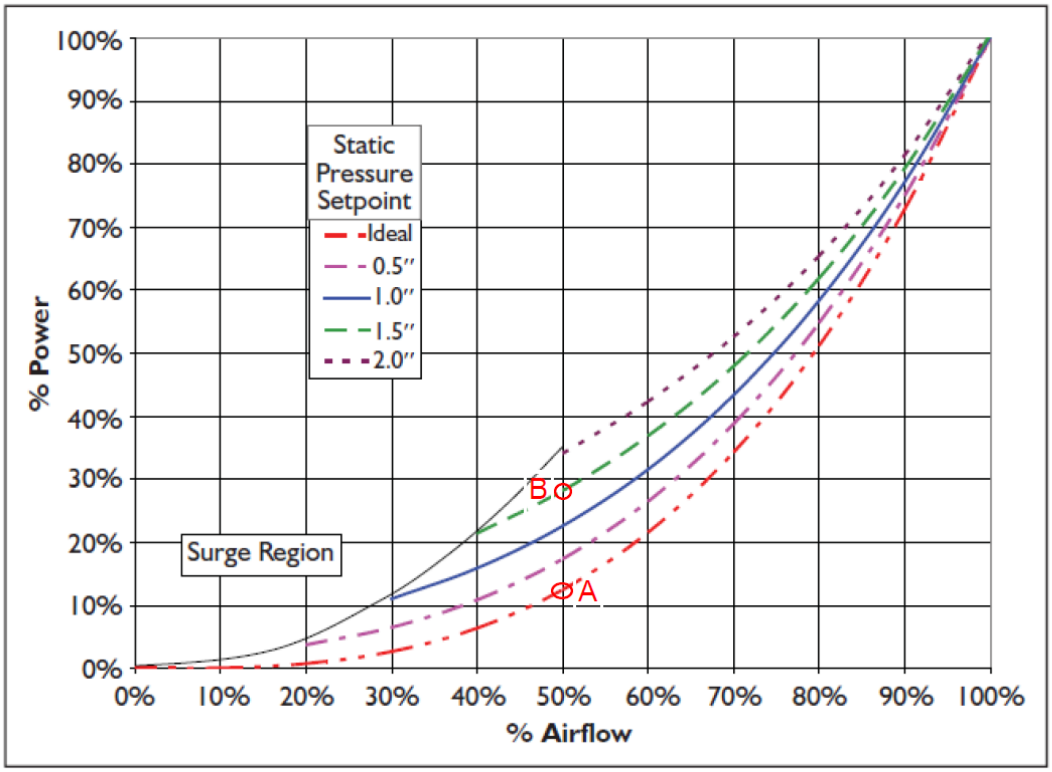

Figure 4. Ideal Pressure Reset Curve

The state-of-art in resetting static pressure is the TR method, and it typically uses maximum VAV damper position as an indication of system cooling load and sets a target of 90% to 95% Open for the maximum damper in the system (Point "A" to Point "B" in Figure 5.)

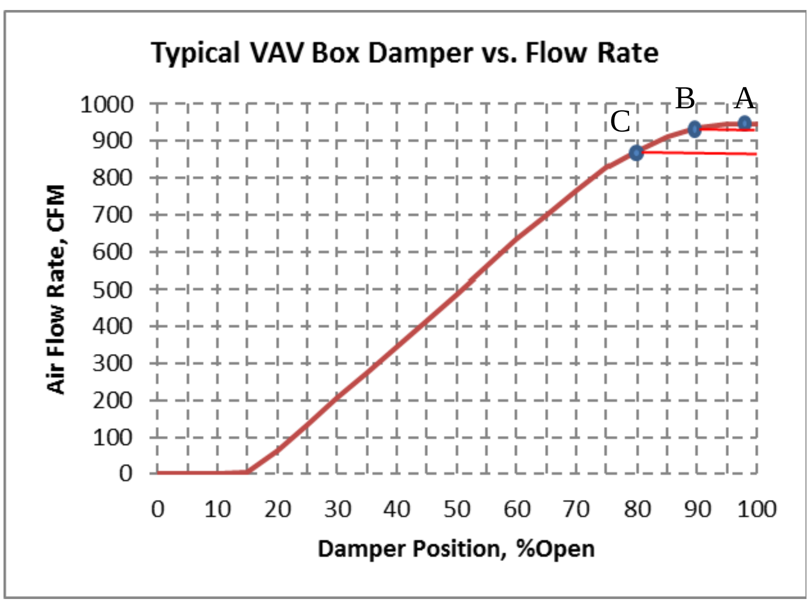

Figure 5. Typical VAV Damper vs. Air Flow Characteristics

The TTR method is an improved version of the TR method. Research done by Dr. Ron Nelson and his students [Nelson, 2011] showed that the target of 95% to 98% threshold value as described in the ASHRAE handbook and other papers might be too high for stable control. Figure 4 shows a typical VAV box curve for damper position vs. air flow rate volume. At higher damper position ranges, large percentage changes in VAV damper position, e.g. point “A” 98% open to point “B” 90% open, can only marginally decrease air flow rate due to the flattened curve in that region. On the other hand, the change in VAV air flow setpoint due to small to modest zone load changes or disturbance could cause a relatively large change in damper command and position, e.g., point “A” to point “B,” or point “A” to point “C.” This significant change in damper command/position will affect the setpoint reset calculation since the damper output itself is usually the result of a PI (Proportional-Integral) control loop output for VAV box cooling and is subject to oscillation if not properly tuned. The PI and PID (Proportional-Integral-Derivative) control methods are standard classical control methods that calculate control output based on the difference between a process variable and a setpoint. The control performances using these methods are highly subject to proper parameter tuning in the field. Further tests also concluded the trim and respond rate change were not a major factor in control stability, but the reset time interval could be a factor. Too short of a time interval, e.g., 1 minute, could easily cause the system to be unstable. While a longer time interval, e.g., 15 minutes, increases system stability, it also may save less energy and respond to system changes too slowly.

In the TTR method, if the maximum damper output or position is within a specified narrow range [Low1, High1], the static pressure setpoint will not change. However, if the damper deviates from this range, the setpoint will be adjusted based on three tiers of ranges ([Low1, High1], [Low2, High2], and [Low3, High3]). The rates of change will be based on preset trim rates (TM1, TM2, TM3) and respond rates (RP1, RP2, RP3) as illustrated in Table 1. The technology is innovative in a sense it recognizes a major factor that causes the instability of static pressure reset control and difficulty in tuning parameters, and provides a solution to alleviate the problem. The approach has better control/adjustment capability for various building types and building mechanical systems. It is a variation and improvement on the state-of-the-art TR method, and it allows a smooth, energy-efficient transition between states. Lower fan speed and more stable control would also result in reduced noise levels compared to constant pressure control and traditional TR method.

Table 1. Illustration of TTR Method Concept

Condition	Response
If MDP > High3	SPSet = SPSet + RP1 + RP2 + RP3
If MDP > High2	SPSet = SPSet + RP1 + RP2
If MDP > High1	SPSet = SPSet + RP1
If MDP < High1 & MDP > Low1	SPSet = SPSet (no change)
If MDP < Low1	SPSet = SPSet - TM1
If MDP < Low2	SPSet = SPSet - TM1 - TM2
If MDP < Low3	SPSet = SPSet - TM1 - TM2 - TM3

MDP: Maximum Damper Command or Position
SPSet: Static Pressure Setpoint
TM1,2,3: Trim Rates; RP1,2,3: Respond Rates; All are positive numbers

Table 2. Test Parameters Used at ISU Hixson-Lied Student Center

Tiered Trim and Respond Method Parameters				
Threshold Group	**High (%Open)**	**Low (%Open)**	**Trim Rate**	**Respond Rate**
High1/Low1	89%	87%	0.005	0.005
High2/Low2	92%	84%	0.02	0.02
High3/Low3	98%	81%	0.03	0.03

Visual Depiction: The TTR method is a control algorithm implementation on a specific DDC system platform. Screenshots of a TTR program implemented on a Johnson Controls METASYS platform at Iowa State University Hixson-Lied Student Center are illustrated in Figure 6~9.

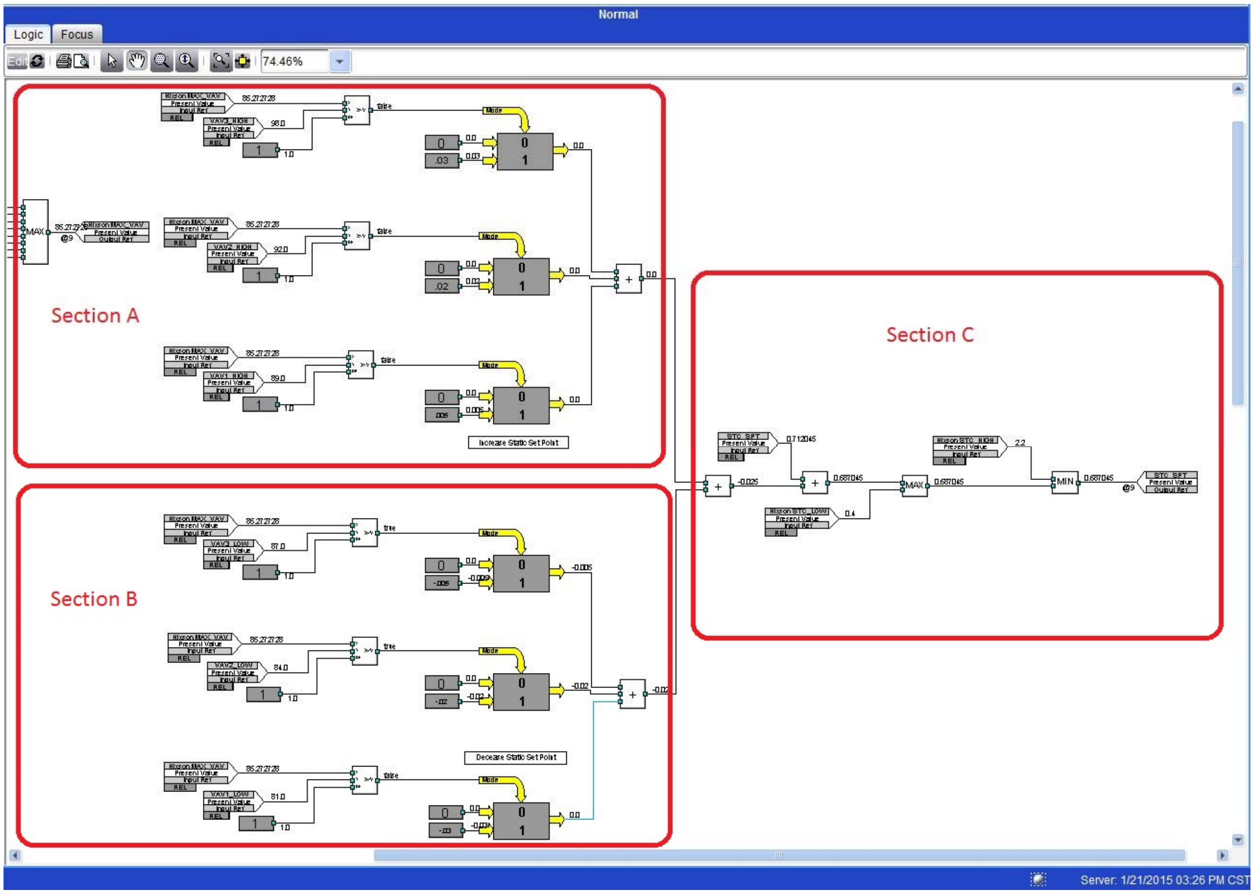

Figure 6. Screenshot of a Sample TTR Program

Figure 6 shows the screenshot of the overall TTR program. It is divided into three "sections," and the enlarged screenshots of those sections are shown in Figure 7~9. The left side of Section A is cut off due to image size, but it is connected to 50^+ VAV box damper positions or command signal outputs from the HVAC system in that building. Section A deals with the logic of comparing the maximum VAV damper position to three high thresholds, and Section B deals with the logic of comparing the maximum VAV damper position to three low thresholds. Section C compares the high and low limit of the static pressure setpoints and calculates a new setpoint based on existing setpoint and trim or respond rate based on Table 2.

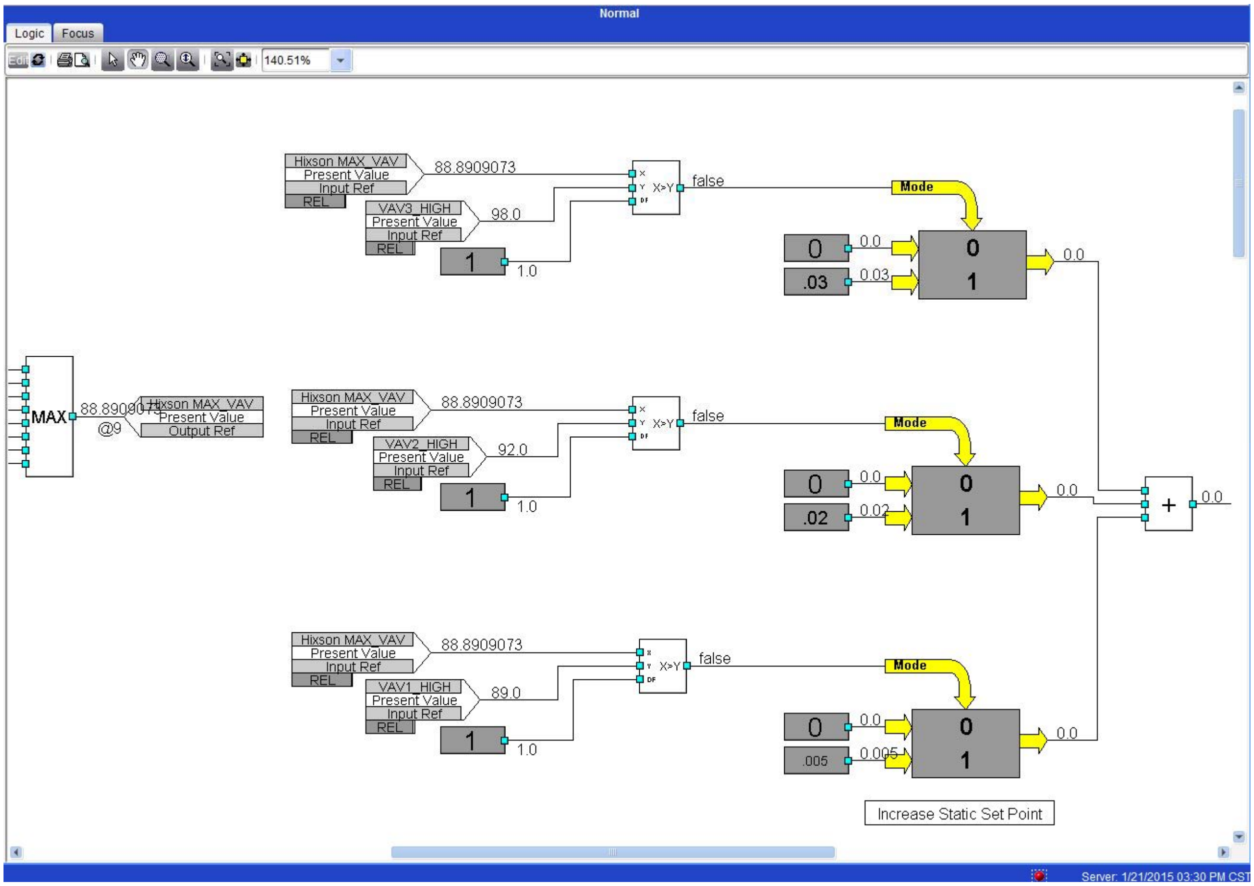

Figure 7. Enlarged Screenshot of Section A of the TTR Program

Figure 7 is a close-up of Section A in Figure 6. The "MAX" calculation module receives the real-time maximum VAV damper feedback or output command signal and stores it in a "Hixson MAX VAV" variable. This value is input to three separate calculation modules, the differences are multiplied by the corresponding "respond rates," then summed together. In this example, the maximum damper position is 88.89%, which is less than 89%, 92%, and 98% open thresholds, so the output on the right side of this section is 0.0 (inch WC) pressure change.

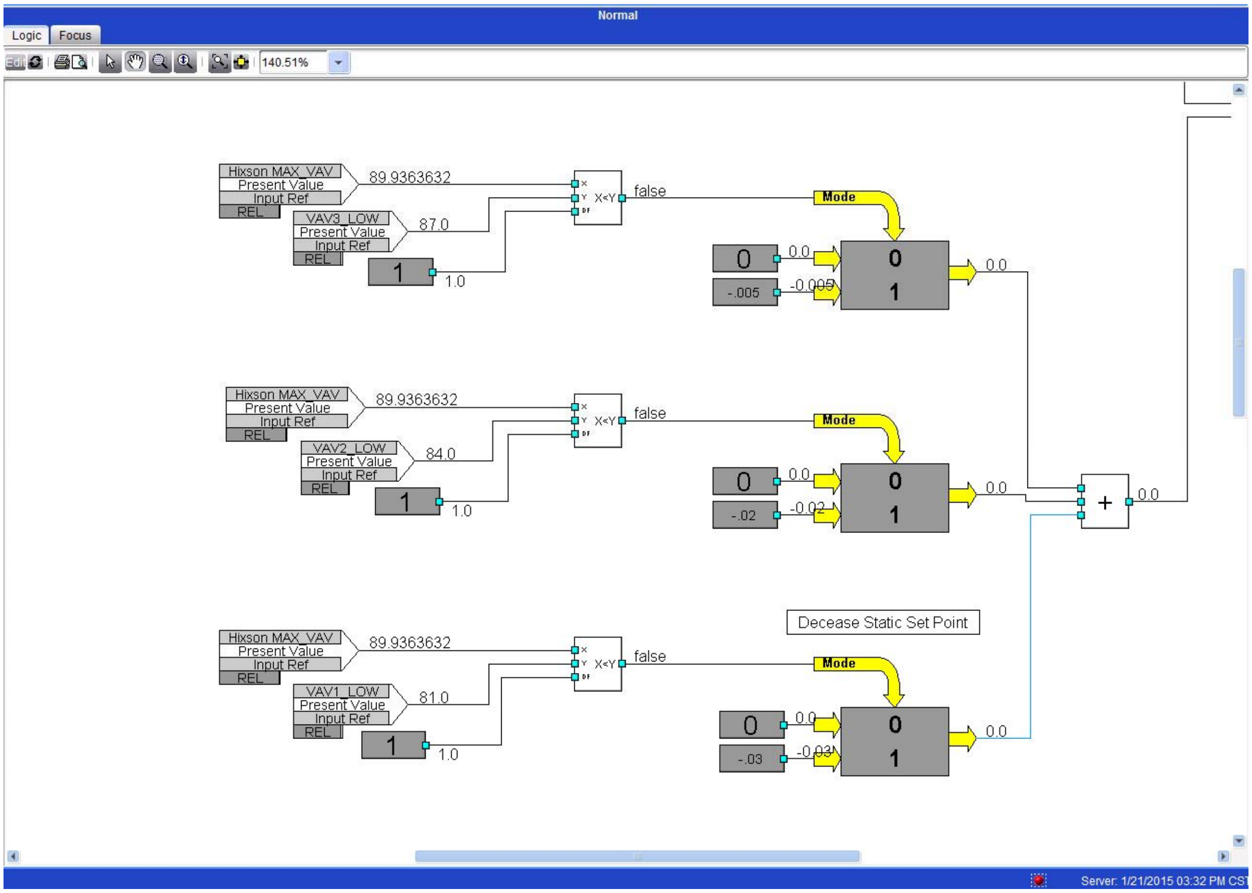

Figure 8. Enlarged Screenshot of Section B of the TTR Program

Figure 8 is a close-up of Section B in Figure 6. The maximum damper position value is input to three separate calculation modules, the differences are multiplied by the corresponding "trim rates," then summed together. In this example, the maximum damper position is 89.9%, which is higher than 87%, 84%, and 81% open thresholds, so the output on the right side of this section is 0.0 (inch WC) pressure change.

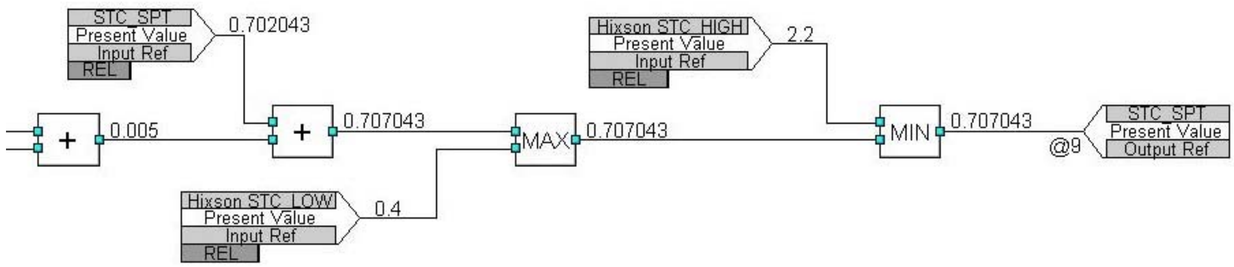

Figure 9. Enlarged Screenshot of Section C of the TTR Program

Figure 9 is a close-up of Section C in Figure 6. The new value (0.707 inch WC) is compared to the high (2.2 inch WC) and low (0.4 inch WC) limits, and then assigned to the static pressure setpoint variable "STC_SPT" to be executed in the next program execution cycle.

Chronological Summary:

Since 1999, ASHRAE Standard 90.1 has required that static pressure setpoint be reset for systems with DDC at the zone level, and California Title 24 Building Energy Efficiency Standards has a similar requirement. A summary of static pressure reset methods in a flow chart format was illustrated by Kimla in 2009 (Figure 10.)

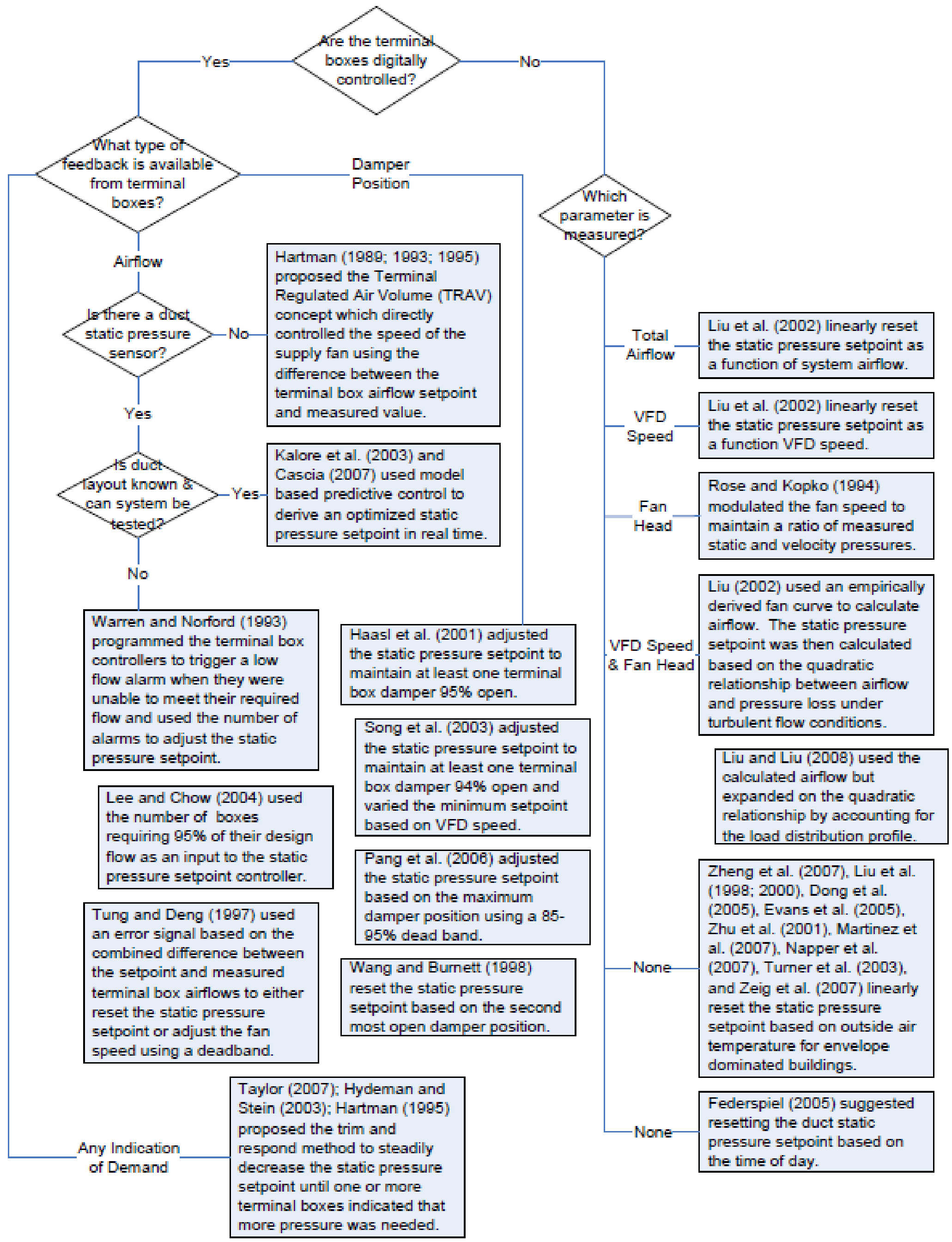

Figure 10. Static Pressure Reset Methods Flow Chart

Future Potential for DoD:

The new TTR method can be readily applicable to a majority of the DoD buildings with forced-air variable-air-volume system design and direct digital control at the zone level. The technology can be implemented in both new and existing buildings. If adopted across all DoD buildings, it is expected the simple payback period for this method to be six months to one year, and reduction in site energy could be 549 GWh per year, which translates to facility operational cost savings of ~$49.4 million dollars per year while reducing CO_2 emissions by 387,347 metric tons.

2.2 TECHNOLOGY DEVELOPMENT

The Tiered Trim and Respond method was the culmination of various comparison tests conducted by Nelson and Householder [Nelson, 2011.] When tested at the Iowa Energy Center's Energy Resource Station, the method outperformed both PID and traditional TR methods in both fan energy savings and static pressure control. When tested at a real building on the Iowa State University campus, the TTR method displayed fan energy savings of 37% over a fixed static pressure strategy. The building has functions similar to many nationwide DoD installations including offices, classrooms and conference rooms.

For 13 weeks, this comparison alternated static pressure strategies weekly, while recording energy use and static pressure control. The TTR method also demonstrated stable static pressure control with no to minimal static pressure oscillation. Another unexpected result of the comparison was the TTR method displayed an improved thermal comfort performance over the FSP method. During this development testing, parameters of the TTR method such as trim and respond rates, damper position tiers, and formulas were established.

In practice, the traditional TR method has been implemented by some major DDC system manufacturers and building controls contractors. However, effectively implementing this method can be tricky. Key problems often include control instability, lack of real examples of programming modules, and demonstrated cost-effectiveness. Nelson investigated the instability in static pressure reset control methods and developed the proposed TTR method. The new method is a revised version of the TR algorithm and has been implemented on a Johnson Controls' METASYS (extended architecture) platform. The three-month demonstration showed approximately 37% of fan energy savings for the TTR method and resulted in prorated savings equal to $3,829 per year while maintaining stable control.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

Performance Advantages:

Compared to fixed static pressure control that is widely used in many existing DoD buildings, the TTR method can significantly increase the efficiency of AHU operations. Compared to the TR method that sees more implementation in new construction, the TTR method is designed to be more stable in control performance and, in theory, more closely tracks building load changes. This performance improvement will likely increase AHU fan service life as well as the acceptance by building operators and facility managers.

Cost Advantages:

The long-term cost advantage for TTR method vs. fixed setpoint is the HVAC system operational cost savings for the TTR method due to fan energy savings. For TTR method vs. TR method, the cost of implementing both approaches and their energy saving potentials are similar. Both methods are in public domain, so there is no licensing or software subscription cost. The first cost and installation cost for implementing the TTR method are hiring a control contractor/technician to perform customized programming on the existing/new DDC systems and commissioning the system. The method is fairly straightforward and simple enough so that the customized programming can be done by a control technician in a few hours for each AHU.

There are minimal operational and maintenance costs involved as these are software implementations and the life of the algorithm is the same as the DDC system for the building, typically 15 to 20 years.

Performance Limitations:

There is a risk that "rogue zones" may be present at the selected demonstration buildings and may limit the effectiveness of this reset strategy. A "rogue zone" refers to a zone controlled by a VAV terminal unit with a damper position that is driving the reset strategy a disproportionately large amount of the time. Unaddressed, even just one or two "rogue zones" may prevent the reset strategy from efficient operation and diminish the energy savings potential. The rogue zone problem can be solved or alleviated with proper mechanical and control system adjustments performed by experienced engineers or commissioning agents. Facility engineers need to monitor system performance closely. Monitoring dashboards that highlight performance degradation, advanced building analytics, or periodic re-commissioning could make TTR effective long-term. The TTR method can also be more robust by adding the capability to ignore certain zones.

The energy savings potential of the static pressure control strategy can be minimal if a facility's existing constant setpoint has been reduced significantly from its design or commissioning setpoint. In some cases, facility managers have significantly reduced air handling setpoint due to occupant complaints of noise or design flaws resulting in the frequent shutdown of units from high static pressure alarm faults. For these air handling units, the TTR method can also have issues with faulting high static pressure alarms.

Cost Limitations:

Building owners should hire qualified control contractors to perform customized programming and implementation of the TTR method. The first cost and installation cost depend on the local control contractor/technician's charge rate and their level of technical expertise to do customized programming on the DDC system platform for the building. Additional costs may arise from routine maintenance on related equipment such as AHU and VAV terminal unit dampers, boiler, and chiller as the TTR method is dependent on the proper operation of the HVAC equipment.

Potential Barriers to Acceptance:

Training is needed for building operators/facility engineers/maintainers to understand the static pressure reset strategy and know what to expect regarding how the AHU fans operate under various load conditions. Management needs to be convinced of the long-term energy impact and cost benefit through case studies, presentations, and publications.

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3.0 PERFORMANCE OBJECTIVES

The TTR performances demonstrated in this project is being evaluated for existing buildings in a building retrofit application. For new construction, static pressure reset (TR, TTR, or other pressure reset method) is prescriptively required, and the incremental first cost is minimal. In both cases, only building control software customization is involved and no HVAC equipment replacement is necessary. A summary of the performance objectives and results are listed in Table 3.

Table 3. Performance Objectives

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives				
Facility Energy Usage	Energy Intensity (MMBtu/ft^2 or kWh/ft^2)	Meter readings of fan energy used by AHUs; Total meter readings by the installations; Square footage of buildings using energy; Zone and outside air temperatures.	On average 30% reduction in AHU fan energy for AHUs selected for fixed setpoint vs. TTR method	**Objectives partially met.** Fan energy savings for 11 AHU/RTUs range from 1.48% to 52.85%. For the five sites, fan energy savings range from 14.4% to 34.8%
Indirect Greenhouse Gas Emissions	Indirect fossil fuel GHG emissions (metric tons)	Total meter readings by the installations; Estimated release of GHG emissions based on electricity saved.	On average 6% reduction in indirect GHG emissions for AHUs selected for fixed setpoint vs. TTR method	**Objectives not met.** Reduction in indirect GHG emissions ranges from 0.6% to 4.7% for the five demo sites.
System Economics	Simple payback years, Savings-to-Investment Ratios (SIRs) for 5, 10, 20 years	Dollar costs for retrofit and training, projected electricity savings, discount rate, local utility rates.	Six months to one-year simple payback; SIR of 6, 12, 22 for 5, 10, 20 years'	**Objectives not met.** Simple payback 1.7 to 14.9 years for the five demo sites. SIRs for 5, 10, 20 years are 2.11, 3.99, 7.04 for Site #2, and 1.03, 1.94, 3.41 for Site #3.

Table 3: Performance Objectives (continued)

Performance Objective	Metric	Data Requirements	Success Criteria	Results
Qualitative Performance Objectives				
User Satisfaction	Degree of Satisfaction (reliability, usability, rate of change in complaints from occupants, stability of TTR method)	User survey results. The number of training hours required of system operators and maintainers.	Similar or better when compared to results collected during the baseline periods (defined in the test design section)	**Objective partially met.** Similar or better at four of the five demo sites. Some complaints at the beginning of demonstration at the other site.
Scalability across the Department of Defense	Overall energy/cost savings in GWh or $ across DOD buildings	The number of DOD buildings for similar demonstration building types. Actual energy savings based on demonstration results. Average electricity rates.	549 GWh per year, which translates to a facility operational cost estimate savings of ~$49.4 million per year	**Objectives not met.** 295 GWh per year energy savings and $29.5 million per year electricity cost savings.
AHU fan static pressure reset strategy technical performance comparison (existing reset vs. TTR method on selected AHUs only)	AHU static pressure setpoint (amplitude, frequency, and rate of change); Zone temperature variations.	Trend data for AHU static pressure & setpoint, VAV damper positions, local weather data, occupancy schedule, zone temperature, and total meter readings by the installations.	For AHUs selected for existing reset method vs. TTR method only, comparative analysis between the two alternatives for several factors. Amplitude: lower is better; Frequency: slower is better; Rate of change of setpoint (track system load); Zone temperature variations: lower the better.	**Objectives partially met.** TTR is generally more stable compared with two TR strategies implemented on two AHUs. However, TTR was not effective on the two AHUs due to various system design and operational issues.

The three key technologies and economic performance objectives for this demonstration are direct energy savings, greenhouse gas reduction, and system economics.

Facility Energy Usage:

Compared to constant static pressure method, it is expected that at least 30% of AHU fan energy savings can be achieved at these five buildings by using the TTR method. The AHU fan energy savings could be translated into significant total building electric energy savings and reduced building energy use intensity (EUI). The energy savings will help DoD better address each military installation's energy needs. Given the square footage of each building, other data required for data analysis includes outside air temperature (because AHU fan energy savings may vary for various building load conditions), average annual fan energy use and building electricity use in kWH, and the total annual building energy intensity in kBTU/ft^2. Several of the key zones' temperatures will also be monitored to ensure occupant comfort is maintained.

Results: fan energy savings for 11 AHU/RTUs comparing fixed pressure vs. TTR method range from 1.48% to 52.85%. At two of the five sites, more than 30% total fan energy savings were achieved. The other three buildings' total fan energy savings were 14.4%, 16.5, and 17.8% respectively. For details, please refer to Section 6.1.1.

Indirect Greenhouse Gas Emissions:

The electricity savings for these buildings will be directly translated into the reduction of GHG emissions in metric tons. The actual percentage of emission reductions may vary for each demonstration site, depending on the building type. It is expected, on average, 6% reduction in indirect GHG emissions for AHUs selected for fixed setpoint vs. TTR method.

Results: Emission reduction percentages at five sites were estimated to be 0.6%, 4.7%, 0.9%, 1.7%, and 1.5% respectively. The lower-than-expected result was mainly due to the fact that four of the five demo sites selected were relatively small in building space or fan energy use was not a big portion of the overall building energy use. For detailed data and discussion, please refer to Section 6.1.2.

System Economics:

The project also demonstrated the system economics of this improved control method. DOE's six Building Life-Cycle Cost (BLCC) Program modules were used to provide computational support for the analysis of capital investments in the five selected DoD buildings. These program modules evaluated the relative cost effectiveness of economic alternatives for buildings and building-related systems/components which typically have higher initial costs but lower operating costs over the life-cycle of the project/building than the lowest, initial cost design. The analysis measured net savings, savings-to-investment ratios, adjusted internal rate of return, and years to payback. Data that needed to be collected for software inputs included the cost to hire local contractors to implement the TTR method, the overall annual electricity savings, local utility rates and rate tariff structure, as well as the discount rate. The useful economic life of this TTR technology should be similar to that of a building automation system installed in the building, typically 15 years. The method is considered to be within the public domain, so there is no software license or subscription fee cost. It is expected the simple payback period for applying this technology is six months to one year. Based on BLCC analysis using the ISU campus building example, the savings-to-investment ratio over 5, 10, and 20-year periods are estimated to be 6.69, 12.62, and 22.15, respectively. These were also the goals for the demonstration sites.

Results: actual demonstration results showed less-than-expected system economics. Actual simple payback years calculated were 5, 1.7, 4.9, 11.8, and 15 respectively for Site #1~5. The savings-to-investment ratio over 5, 10, and 20-year periods are 2.11, 3.99, 7.04 for Site #2, and 1.03, 1.94, 3.41 for Site #3, and could not be calculated for the other three locations. For details, please refer to Section 6.1.3.

User Satisfaction:

Local facility engineers/building operators were given a survey about the degree of satisfaction with the technology. User satisfaction helps assess the long-term usability of this technology to building owners/operators.

Results: At three of the five sites, users did not have any additional complaints or differences in comfort level between the existing pressure control method and the TTR method. At one site at the beginning of the demonstration, significant noise, vibration, and tripping of a high static pressure sensor occurred when the static pressure was set by TTR to approach the design values. The problem is mainly due to an improperly designed HVAC system rather than a problem caused by TTR method. For details, please refer to Section 6.1.4.

Scalability across the Department of Defense:

Based on demonstrated energy savings from the five selected DoD buildings, more accurate energy savings potential across all DoD buildings can be assessed.

Results: 295 GWh per year energy savings and $29.5 million per year electricity cost savings were projected based on demonstration results. These are lower than estimated in the proposal. For details, please refer to Section 6.1.5.

AHU fan reset strategy performance comparison:

On selected AHUs that were controlled by existing static pressure control strategies (implemented by different control vendors), the existing reset strategies were compared to TTR method by studying the amplitude, frequency, and rate of change for AHU supply static pressure vs. its setpoint and compared with building load profile. The impact on occupant comfort (indicated by zone temperature variations) was also studied.

Results: TTR is more stable compared with two TR strategies implemented on two AHUs. However, TTR was not effective due to various system design and operational issues so the comparison result of control stability in this demonstration is mute. For a detailed discussion, please refer to Section 6.1.6.

4.0 FACILITY/SITE DESCRIPTION

In this chapter, the five Iowa Army National Guard facilities selected for this demonstration and their HVAC equipment and building controls' system configurations and conditions are described.

4.1 FACILITY/SITE LOCATION AND OPERATIONS

Demonstration Site Description:

Five Iowa National Guard facilities that were selected for this demonstration.

Site #1: Joint Forces Headquarters (JFHQ)

Figure 11. Joint Forces Headquarters (JFHQ)

Asset Name	BUILDING 3850
Asset Description	NATIONAL GUARD/RESERVE CENTER BUILDING
Asset Code	19901-A0100
Real Property Unique Identifier	254999
Predominant Category Code	17142
Installation Status Report	Q1 90
Interest Type Code	Federal
Facility Built Date	10/21/1994
Acquisition Cost	$12,554,026.00
Total Square Feet	237,126 Square Feet
Number of Floors	4

Figure 12. Joint Forces Headquarters (JFHQ) Basic Building Information

The Iowa Army National Guard Joint Forces Headquarters (JFHQ) is located at 7277 Northwest 70th Avenue in Johnston, Iowa. This support facility (237,126 sq. ft.) houses several IAARNG Executive Leadership Offices, Directorates, Drill Hall, Motor Vehicle Service Bays, Classrooms, and Department of Homeland Security components including Iowa Homeland Security and Emergency Management. Broadly speaking, the facility has DoD-wide applicability in that every U.S. state has similar facilities serving similar emergency response and readiness support functionalities.

Site #2: Muscatine Armed Forces Reserve Center (AFRC)

Figure 13. Muscatine Armed Forces Reserve Center (AFRC)

Asset Name	ARMED FORCES RESERVE CENTER
Asset Description	ARMED FORCES RESERVE CENTER BUILDING
Asset Code	19536-AFRC0
Real Property Unique Identifier	1099853
Predominant Category Code	17142
Installation Status Report	Q1 100
Interest Type Code	State
Facility Built Date	9/9/2011
Acquisition Cost	$7,710,964.96
Total Square Feet	37,392 Square Feet
Number of Floors	1

Figure 14. Muscatine Armed Forces Reserve Center (AFRC) Basic Building Information

The Muscatine Armed Forces Reserve Center is located in Muscatine, Iowa. This LEED Silver Certified support facility (37,392 sq. ft.) houses IAARNG and Army Reserve Units' administrative offices side-by-side and provides storage, kitchen, classroom, physical fitness facilities, and vehicle maintenance space. Approximately 100 area soldiers from IAARNG and U.S. Army Reserve train at the facility. Community groups also rent the facility for events and functions. In general, the facility has DoD-wide applicability in that hundreds of BRAC sites exist across all Agencies (Army Corps of Engineers, Defense Logistics Agency, Department of Defense, National Guard, U.S. Air Force, U.S. Army, and U.S. Navy).

Site #3: Waterloo Readiness Center (RC)

Figure 15. Waterloo Army Aviation Support Facility (AASF/ARMORY)

Asset Name	AC MAINT HGR
Asset Description	AIRCRAFT MAINTENANCE HANGAR
Asset Code	19D65-AASF2
Real Property Unique Identifier	562795
Predominant Category Code	21110
Installation Status Report	Q1 99
Interest Type Code	State
Facility Built Date	1/1/1974
Acquisition Cost	$1,376,203.00
Total Square Feet	84,764 Square Feet
Number of Floors	2

Figure 16. Waterloo Army Aviation Support Facility Basic Building Information

The Waterloo Readiness Center (34,185 sq. ft.) is an addition to a larger Army Aviation Support Facility (84,764 sq. ft.) that was installed in 1974. This aviation and maintenance support facility and Armory houses aircraft and personnel offices, latrines, storage, kitchen, classroom, physical fitness facilities, and aviation/hangar equipment testing, training and maintenance space. From a DoD-wide applicability standpoint, hundreds of similar aviation support facilities exist and stand to benefit economically from the implementation of the proposed method.

Site #4: Boone Readiness Center (RC)

Figure 17. Boone Readiness Center

Asset Name	ARNG ARMORY
Asset Description	NATIONAL GUARD READINESS CENTER
Asset Code	19A25-ARMRY
Real Property Unique Identifier	245050
Predominant Category Code	17180
Installation Status Report	Q1 94
Interest Type Code	State
Facility Built Date	1/1/1963
Acquisition Cost	$219,287.00
Total Square Feet	77,321 Square Feet
Number of Floors	1

Figure 18. Boone Readiness Center Basic Building Information

The Boone Readiness Center is located in Boone, Iowa. This support facility (77,321 sq. ft.) houses administrative offices, drill hall, latrines, storage, kitchen, classroom, physical fitness facilities, and vehicle maintenance space. From a DoD-wide perspective, thousands of similar readiness facilities exist and stand to benefit economically from the implementation of the proposed method.

Site #5: Des Moines Military Entrance Processing Station (MEPS)

Figure 19. Des Moines Military Entrance Processing Station (MEPS)

Asset Name	BUILDING 1212
Asset Description	MILITARY ENTRANCE PROCESSING STATION
Asset Code	19901-S7100
Real Property Unique Identifier	252497
Predominant Category Code	61001
Installation Status Report	Q1 97
Interest Type Code	Federal
Facility Built Date	10/11/2008
Acquisition Cost	$4,044,171.87
Total Square Feet	28,200 Square Feet
Number of Floors	1

Figure 20. Des Moines Military Entrance Processing Station Basic Building Information

The Des Moines Military Entrance Processing Station is located at Iowa National Guard Camp Dodge in Johnston, Iowa. This facility (28,200 sq. ft.) is one of a network of 65 MEPS located nationwide and in Puerto Rico. A separate Department of Defense agency, USMEPCOM is comprised of two geographical sectors and staffed with personnel from all military services. Equipped with administrative offices, exam, screening and waiting rooms, the mission of USMEPCOM and the Des Moines MEPS is to process individuals for enlistment or induction into the armed services, based on DoD-approved peacetime and mobilization standards.

Key Operations:

The demonstration of the TTR method should not have a major impact on building occupants.

Location/Site Map:

A map of the demonstration site locations is shown below:

Figure 21. Site Maps for the Five Demonstration Sites

4.2 FACILITY/SITE CONDITIONS

Site #1: Joint Forces Headquarters

The JFHQ is a 20-year-old building and is mainly served by 12 AHUs: six of them are constant-air-volume systems, and the other six are VAV systems with a total of 208 VAV terminal units. Five of the VAV AHUs (AHU-1, AHU-2, AHU-3, AHU-4, AHU-9, and AHU-12) are penthouse units with supply fans of 20 MHP or less. These 5 AHUs share two 125 ton chillers with evaporative cooling. The other VAV AHU, AHU-12, is a custom built unit in the basement of the facility. The unit is comprised of 4 supply and four return fans and is served by a single 300-ton chiller with an attached cooling tower. The facility utilizes a radiant in-floor heating system delivering the only source of heating for a majority of the VAV zones, with cooling service provided by the VAV ductwork systems only. All AHUs and radiant in-floor heating system share a single gas-fired boiler.

The building automation system controlling the HVAC equipment was a Schneider Electric/TAC/Invensys's I/A series system with fixed static pressure control. In 2014, the building control system underwent a complete upgrade and commission. Currently, the new building control system is Distech Controls' EC-Net^{Ax} web-based multi-protocol Building Automation and Energy Management system. The new control implements AHU static pressure reset based on a modified version of the Trim and Respond (TR) method.

The six air handling units studied at this facility are AHU-1, AHU-2, AHU-3, AHU-4, AHU-9, and AHU-12. The total number of VAV boxes for these six AHUs is 208. Only a small number of these VAV boxes provide reheat through electric heating coils. Most heating is done through a separate radiant floor heating system. The five penthouse units share a single chiller, while the largest, custom built unit has its chiller with a cooling tower. These AHUs typically operate during normal occupied hours from 5:00 am to 6:00 pm. The AHU-12 operates 24 hours per day. During the weekend, building occupancy is based on scheduled meetings and events.

The VFDs adjusting the speeds of these supply and return fans are ABB ACH550, Danfoss VLT 6000, and Schneider Electric E-Flex. They are in relatively good condition.

This building is part of the Camp Dodge facilities and maintained mainly by two IAARNG facility engineers. They are also responsible for over 200^+ other buildings in Camp Dodge – the main campus for the Iowa National Guard. Due to limited resources, they typically find out issues and problems based on building occupant complaints and rarely have time to monitor each building's HVAC and control performance in detail. When problems occur, and they do not have the time or ability to correct, HVAC equipment or control contractors are contacted for help.

Site #2: Muscatine Armed Forces Reserve Center

The Muscatine AFRC is a new LEED Silver facility and is served by five Rooftop Units (RTUs), three of which are VAV system configuration with 36 VAV terminal units in total. The building control system is Johnson Controls' METASYS system. The first RTU, RTU-1, serves 3 VAV zones, all in kitchen areas. RTUs 3 and 4 serve the east and west portions of the facility, with 17 and 16 VAV boxes, respectively. RTU-1 normal occupied hours are from 6:00 am to noon, while RTU-2 and RTU-3 normal occupied hours are from 6:00 am to 6:00 pm. These packaged RTUs along with the building heating water supplies share two boilers. This facility's building control system does have basic static pressure reset control in place. The existing control used a maximum of heating and cooling demand signal to reset RTU static pressure between the minimum and maximum preset static pressure values. On normal days, there are only a few soldiers in the building. Typically scheduled training for soldiers from IAARNG and U.S. armed force reserves occurs on weekends on an irregular schedule.

The VFDs adjusting the speeds of these supply and return fans are YASKAWA J1000 and V1000 models that are preinstalled with the packaged units. These VFDs are relatively older models and cannot directly communicate digitally with building control systems.

One IAARNG facility engineer is responsible for this building and other IAARNG's 20^+ buildings' HVAC and controls operations and maintenance in the southeast quadrant of State of Iowa. The engineer frequently travels throughout the region to resolve issues and problems for these buildings and returns to Camp Dodge for regular meetings each week at Iowa Army National Guard central campus. At times, it is necessary for him to call local HVAC or control contractors to fix equipment or building automation system related technical issues.

Site #3: Waterloo Readiness Center

The Waterloo AASF/ARMORY was initially built in 1974 and is served by three RTUs, with one of them, RTU-1, being a VAV system that supplies air to 14 VAV terminal units. RTU-1 is managed by Johnson Controls' METASYS system. This building did not have pressure reset control before this demonstration project. The facility's normal HVAC equipment operation hours are from 5 am to 4 pm, even though RTU-1 runs 24 hours per day.

Similar to VFDs at the Muscatine site, the VFDs at the Waterloo site are YASKAWA GPD 315/V7 model that are preinstalled with the packaged units. These VFDs cannot directly communicate digitally with building control system. The return fan VFD was not running before the official demonstration.

Similar to the Muscatine AFRC, there is one IAARNG facility engineer responsible for this building and the other IAARNG's 20^+ buildings' HVAC and controls operations and maintenance in the north-east quadrant of State of Iowa. The engineer frequently travels throughout the region to resolve issues and problems for these buildings and returns to Camp Dodge for regular meetings each week at Iowa Army National Guard central campus. Coordination with local HVAC or control contractors is sometimes needed to fix equipment or building automation system related technical issues.

Site #4: Boone Readiness Center

The Boone Readiness Center added an addition and received two major renovations since initially built in 1963. The most recent in 2005 included installation of its current HVAC equipment and DDC system. The facility is served by 3 AHUs, two (AHU-1 and AHU-2) of which are VAV systems serving the north and south areas of the facility. Both AHUs are factory built units, serving 66 VAV terminal units in total (31 and 35 for AHU-1 and AHU-2 respectively) and are managed by Trane's Tracer Summit building automation system. This building did not have pressure reset control in place. Both AHUs run from 5 am to 4 pm in the summer and 4 am to 4 pm in the winter.

The VFDs for these two AHU supply and return fans are Trane TR 200 and Square D Econoflex models.

The Boone RC heating and cooling plants are shared between the facility's three air handling units. The facility regularly has occupancy functions lasting throughout the weekend hours. Before the official demonstration, several mechanical and control issues regarding the VAV system were found and resolved by re-commissioning. Issues were related to closed fire dampers, bad temperature sensors, inaccurate VAV box airflow sensors, and inappropriate control parameter settings.

Similar to the Muscatine AFRC and Waterloo Armory, there is one IAARNG facility engineer responsible for this building and the other of IAARNG's 20^+ buildings' HVAC and controls operations and maintenance in the northwest quadrant of State of Iowa. The engineer frequently travels throughout the region to resolve issues and problems for these buildings and returns to Camp Dodge for regular meetings each week at Iowa Army National Guard central campus.

Site #5: Des Moines Military Entrance Processing Station

The Des Moines MEPS is served by one AHU with 34 VAV terminal units and is controlled by Schneider Electric/TAC/Invensys's I/A series building control system. The AHU also contains a heat recovery unit, with heating service supplied by two boilers and cooling service by a single 72-ton chiller. The boilers and chillers are controlled by a separate control system due to system upgrade. The building's normal HVAC occupancy schedule is from 5:20 am to 9:20 pm on weekdays. On weekends, the building is usually unoccupied, and no HVAC system is set to run.

The VFDs AHU-1 supply and return fans are ABB ACH550 and are in good condition.

This building is part of the Camp Dodge facilities. Problems with occupant discomfort are often reported to the two facility engineers via phone calls.

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5.0 TEST DESIGN

This chapter provides the detailed description of the system design and testing conducted during the demonstration.

Fundamental Problem:

For commercial buildings with VAV systems, the commonly used fixed setpoint control of AHU supply air duct pressure is not an energy efficient control strategy. Current state-of-the-art static pressure reset strategy (specifically the TR method and its variations) may experience stability issues and therefore could be less efficient in reducing fan energy or could compromise occupant comfort. The proposed TTR method may be an improved approach that replaces fixed static pressure control and TR method.

Demonstration Question:

How much can fan energy be saved by implementing the TTR method compared to the fixed static pressure method at five DoD demonstration sites? What are the system economics for implementing the TTR method? What is the technical performance (regarding pressure setpoint stability and occupant comfort) of the TTR method compared to existing static pressure reset strategies at these demonstration buildings?

5.1 CONCEPTUAL TEST DESIGN

Hypothesis:

1) The proposed TTR method will save 30% AHU fan energy compared to fixed static pressure control. 2) The proposed TTR method has superior system economics, so it can be widely adopted DoD-wide. 3) TTR method can be more stable in controlling AHU static pressure while saving energy without compromising occupant comfort.

Independent variable:

Control logic for setting AHU static pressure at five DoD demonstration sites. Existing building automation system programs were customized to add the control logic of the new TTR method in resetting AHU static pressure.

Dependent variable(s):

All variables used in meeting performance objectives are described in Chapter 3. These include but are not limited to:

- Power readings of fan energy used by AHUs
- Square footage of buildings
- Zone temperatures
- Total building meter readings by installation
- Dollar costs for retrofit, which includes DDC program customization, troubleshooting, control and mechanical system changes (if necessary), maintenance and repair, and training
- User survey results
- The number of training hours required for system operators and maintainers

- Trend data for AHU static pressure and setpoint, VAV damper positions

Controlled variable(s):

- Number of DoD buildings for similar demonstration building types
- Electricity rates
- Discount rate
- Local weather data
- Building occupancy schedule

Test Design:

The demonstration was conducted at five Iowa Army National Guard facilities by the method of sequential testing, switching control methods once every two weeks, over a one-year period. The comparisons were between fixed static pressure control and TTR method for a majority of the AHUs, and between existing pressure reset methods and TTR method for a small number of selected AHUs.

Dependent and independent variables were trended and collected during the one-year demonstration period. The cost data for hiring building control system vendors to perform customized control programming, training, and troubleshooting before and during the official demonstration were also collected. Local weather information was downloaded from local weather station website for weather normalization of energy comparisons.

Test Phases:

Detailed phases/tasks for the demonstration are described below:

- **Task 1: Identify five demonstration sites**

  By collecting and analyzing engineering drawings and communicating with control system vendors for potential sites for demonstration, the team collaboratively identified and confirmed the five IAARNG buildings that meet the applicability of using the TTR method. It was desirable that the five buildings represent different DoD building types, sizes, and DDC systems. The five sites studied are described in Chapter 4.

- **Task 2: Review building mechanical and control systems and design energy monitoring system**

  Mechanical system engineering drawings and building control system documents were collected for the five demonstration sites and examined by team members. A majority of the demo AHUs (eleven of thirteen) were used to demonstrate fan energy savings for TTR method vs. fixed static pressure control. The other two AHUs were used to compare energy and control performance of TTR method vs. existing TR reset.

  The most important data points in calculating energy savings are the AHU supply and return fan powers. As described in Chapter 4, VFDs for AHU/RTU supply and return fans in these demonstration sites vary by manufacturer and model. More recent models have the capability to measure and display VFD output-side power (fan power only), while some older models do not have that capability. During this project, fan power data were collected in two ways:

1) VFD data were trended via the building automation system at 1 or 2 minute intervals; or 2) VFD power were measrued and logged through HOBO data loggers and newly installed watt transducers. Other data points, such as AHU static pressure and setpoint; VAV damper position or command values; AHU/RTU and building occupancy schedules; and zone temperatures, were recorded by enabling trends from building automation systems for these buildings. The building electric meter data were obtained from the local building-level smart sub-meter (PowerLogic™ Series 400 and 800 Power Meter). These meters have local data storage and networking capability.

The data trended by the building automation systems were processed by proprietary software tools or customized excel spreadsheet to convert from raw data format to easy-to-read format. Since these building control systems are on isolated networks not connected to the internet and not connected to a military network, these data were collected by local IAARNG facility engineers and hand-delivered to the PI regularly. For VFD data collected via HOBO U30 data logger, data were transferred via the commercial cellular network to the data logger manufacturer's data server every 10 minutes and could be remotely accessed by the research team members. All sensors and watt transducers were certified by the manufacturer or calibrated to meet the appropriate accuracy requirements, and the data was sampled, collected and stored at a minimum of once every 15 minutes.

- **Task 3: Monitoring instrumentation procurement and installation**

  For older models of supply and return fan VFDs, the HOBO U30 data loggers and watt transducers were procured and installed at the demonstration sites by IEC staff. The U30 monitoring systems were carefully commissioned and monitored for several weeks to ensure data collection, storage, and remote communication capabilities were reliable. For new models of the supply and return fan VFDs, BACnet communication modules were procured and installed by local building control system vendors to enable their communication with the building automation systems. HVAC monitoring points necessary for analyzing system performance were also trended at 1 or 2-minute sample intervals.

- **Task 4: Customized software programming and implementation**

  Detailed specifications, the scope of work, and procedures for implementing the TTR method were compiled by research team members. Four local building control system vendors for these five demo sites were contacted to perform the control software customization on the existing building control systems. The scope of work for these control vendors included: 1) TTR method software programming, commissioning, and troubleshooting; 2) HVAC trend data setup; 3) operator training; and 4) system maintenance during the demonstration period. Detailed invoices listing actual labor hours spent on each task, labor rate, and itemized hardware/software costs were required.

- **Task 5: System troubleshooting, facility operator training, energy data monitoring and collection:**

  After the TTR control programs were implemented, TTR functional tests were conducted and passed, and mechanical and control system performances were closely monitored to make sure the TTR algorithms were correctllly programmed. Mechanical or control issues were identified and fixed before the one-year official demonstration began.

  Local facility engineers were trained after the TTR method was programmed and debugged. The training was face-to-face, on-site, focusing on teaching the basic concept of TTR, how to monitor system performance through building system trend charts, and the impact of the new method to their building energy system's dynamics.

  AHU fan energy data were collected using the HOBO U30 data logger with watt transducers and through the existing building control system with added VFD communication cards installed on fan VFDs. Building utility meter data were collected by Iowa Army National Guard state energy manager. Relevant HVAC monitoring trend data were collected by adding/enabling trend studies for these points in the building control systems.

- **Task 6: Survey data collection:**

  After three months and six months from the beginning of the demonstration period, the facility engineers/building operators were interviewed and completed surveys answering questions related to their experience with the existing static pressure control method and the TTR method. The questions were designed by the project PI according to performance objectives "User Satisfaction." The facility engineers were given survey forms to collect information on occupant comfort complaints during the entire demonstration period. At the end of the demo, PI met with these facility engineers again, presented preliminary results, and asked them if they wanted TTR algorithm to be left running permanently at these demo sites.

- **Task 7: Data analysis:**

  Data collected from the five demo locations in the one-year demonstration period were used in assessing the performance objectives described in Chapter 3. For facility energy and AHU fan energy use, valid one-year AHU fan power data for fixed pressure control and TTR control methods were averaged to daily and weekly results for energy savings percentage comparison. The daily total fan energy use data then was normalized using the weather data collected from nearby weather stations to project annual total fan energy use for both fixed pressure and TTR methods.

  The control method performance was analyzed using data collected directly from the building control system and presented in time-series graphics. AHU static pressure setpoints' amplitude, frequency, rate of change, and zone temperature variations compared to zone temperature setpoints were compared on daily charts for existing reset method vs. TTR method.

The EPA's web-based "Greenhouse Gas Equivalencies Calculator" was used to convert electricity savings (in kWh) to metric tons of carbon dioxide reduced. The system economics of using the technology was analyzed following NIST building life cycle cost program procedures and using the BLCC software to evaluate overall cost and benefit.

Interview results with energy managers and facility engineers were compiled and summarized as anecdotal observations of user satisfaction for the TTR method.

Building statistical data of Iowa National Guard facilities was studied from the Iowa Public Building Benchmarking database. Combined with actual energy savings from five demonstration sites, more accurate energy savings estimates were determined across all applicable DoD sites.

- **Task 8: Technology Transfer and Reporting:**

  Technology transfer tasks were carried out during the project period and continued after project completion. During the project period, seminars, conference and technical paper session presentations were made at the ASHRAE national conference introducing the TTR method and DoD ESTCP demonstration case study progress and results. Sample TTR programs and functional test form are available in the appendix of this report.

5.2 BASELINE CHARACTERIZATION

Since the demonstration was designed to be conducted by the method of sequential testing with switching control methods automatically once every two weeks over a one-year period, the baseline period was defined as the first of the two alternating periods. For comparison of fixed pressure control vs. TTR, the baseline period was the period running the fixed pressure control method. For comparison of existing reset method vs. TTR, the baseline period was the period running the existing reset control method. Because there were no mechanical system changes made during the control method switchover, and the baseline methods are from original control system settings, the baseline represents typical operating conditions and adequate time to cover seasonal variations.

<u>Reference Conditions</u>:

Data collected during baseline periods include building utility meter data, selected DDC system points, AHU fan energy, and local weather data.

<u>Baseline Collection Period</u>:

The planned amount of time to collect baseline data was approximately half of the one-year demonstration period. However, actual valid the data gathered may be somewhat less due to issues with building control systems, HVAC network, computer hardware, or data collection software.

<u>Existing Baseline Data</u>:

No data was collected before the one-year demonstration began.

Baseline Estimation:

The estimation of the annual building and AHU fan energy use for the baseline period was projected based on actual results from the baseline period during the one-year demonstration.

Data Collection Equipment:

HOBO U30 data loggers and watt transducers were used to collect one AHU supply fan power data at Site #1 (JFHQ), both supply and return fan power data at Site #2 (Des Moines MEPS), all of the supply and return fan power data at Site #3 and Site #4 (Muscatine AFRC and Waterloo RC sites respectively.) All other AHU fan power data was collected through the existing building control system by communicating with AHU fan VFD and collecting and trending their fan power data. Each facility's building utility smart meter data were used to collect building level energy use. Other HVAC data points for comparing control method performances were collected through the existing DDC systems. It is worth mentioning that for Site #2 (Des Moines MEPS), during the demonstration period, the BAS data trending function failed due to a server networking issue. A Building Robotics's Trendr box was procured and set up to communicate with the building control system as a replacement for the BAS data trending/collection function.

5.3 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

This section describes the components and provides a depiction of the demonstrated system.

System Design:

The demonstration was conducted by customizing existing commercial building control programs and comparing them with the fixed static pressure control or existing reset method based on Table 4. The results show AHU energy savings and control performance of the proposed TTR method; an improved AHU static pressure reset method for existing building control system at the demonstration sites. Table 4 summarizes five demonstration sites, building automation system names for each location, and demonstration comparisons.

Table 4. TTR Demonstration Comparisons

	Demonstration Site	Existing DDC System	# of AHUs	# of VAV Boxes	# of AHU for Fixed Setpoint vs. TTR	# of AHU for Existing Reset vs. TTR
1	JFHQ	Distech Controls	6	208	4	2
2	Muscatine AFRC	JCI Metasys	3	36	3	0
3	Waterloo RC	JCI Metasys	1	14	1	0
4	Boone RC	Trane Tracer Summit	2	66	2	0
5	Des Moines MEPS	Invensys IA Series	1	34	1	0

To demonstrate the fan energy savings and new control algorithm's control performance, Tiered Trim and Respond (TTR) algorithm was implemented at each of the five sites. One full year of data were collected at 1-minute or 2-minute intervals for the HVAC control and monitoring points for data analysis:

- AHU and zone occupancy status
- AHU static pressure set point
- AHU static pressure
- AHU supply fan and return fan power or energy consumption
- AHU supply fan and return fan speed
- All zone temperatures and their heating/cooling set points
- All zone VAV damper positions (or VAV damper control command value)

Two different static pressure control methods were programmed into the building control systems to be automatically switched every two weeks to minimize the overall weather conditions throughout the year.

Components of the System:

For each demonstration site, major elements of the system included: AHU/RTU supply and return fans and their speed controlling variable frequency drives, VAV terminal unit damper commands or positions, building control system and its control sequence. For demonstration, data loggers and watt transducers recorded and transmitted VFD power data and various software recorded and converted long-term HVAC system raw data to a user-friendly format which was an important part of the demonstration.

System Depiction:

Site #1 Joint Forces Headquarters (JFHQ)

This site's BAS is Distech Controls' EC-NetAX™ native BACnet, web-based multi-protocol Building Automation and Energy Management Platform. There are six VAV AHUs (AHU-1, 2, 3, 4, 9 and 12) and a total of 208 VAV terminal units in this building. The typical control schematic diagram for AHU-1, 2, 3 and 4 is illustrated in Figure 23. The control schematic diagram for AHU-9 is illustrated in Figure 24. The schematic diagrams for AHU-12 controls are illustrated in Figures 25 and 26. AHUs 1, 2, 3 and 4 are similar in size and zones they serve, AHU-9 is the smallest unit, and AHU-12 is the largest unit. AHU-2 was used to compare "traditional" TR method vs. TTR, and AHU-3 was used to compare existing TR (a variation of TR method) vs. TTR method, while the other four AHUs were used to compare fixed static pressure vs. TTR method. The control modes for these AHUs switched on a once every two weeks schedule during the one-year demonstration period.

On most of the existing supply/return fan VFDs (ABB model), a BACnet communication card can be added to bring in supply/return fan power points to the existing BAS. Figure 22 is a picture of a typical AHU fan VFD displaying its output power readings. The building control vendor who did the recent building control system upgrade at this site was hired to do customized programming and training, as well as adding supply/return fan power points and other relevant HVAC data points to record historical data at 1-minute intervals.

Figure 22. An AHU fan VFD

The AHU-2 supply fan required the installation of a HOBO U30 data logger and compatible watt transducers to measure fan power because its VFD model (Danfoss VLT6000) did not have the capability to communicate with the existing building control system via BACnet. This supply fan power data was logged at 1-minute intervals and transmitted to Onset's data server via commercial cellular data communication once every 10 minutes. The data was downloaded remotely for data analysis.

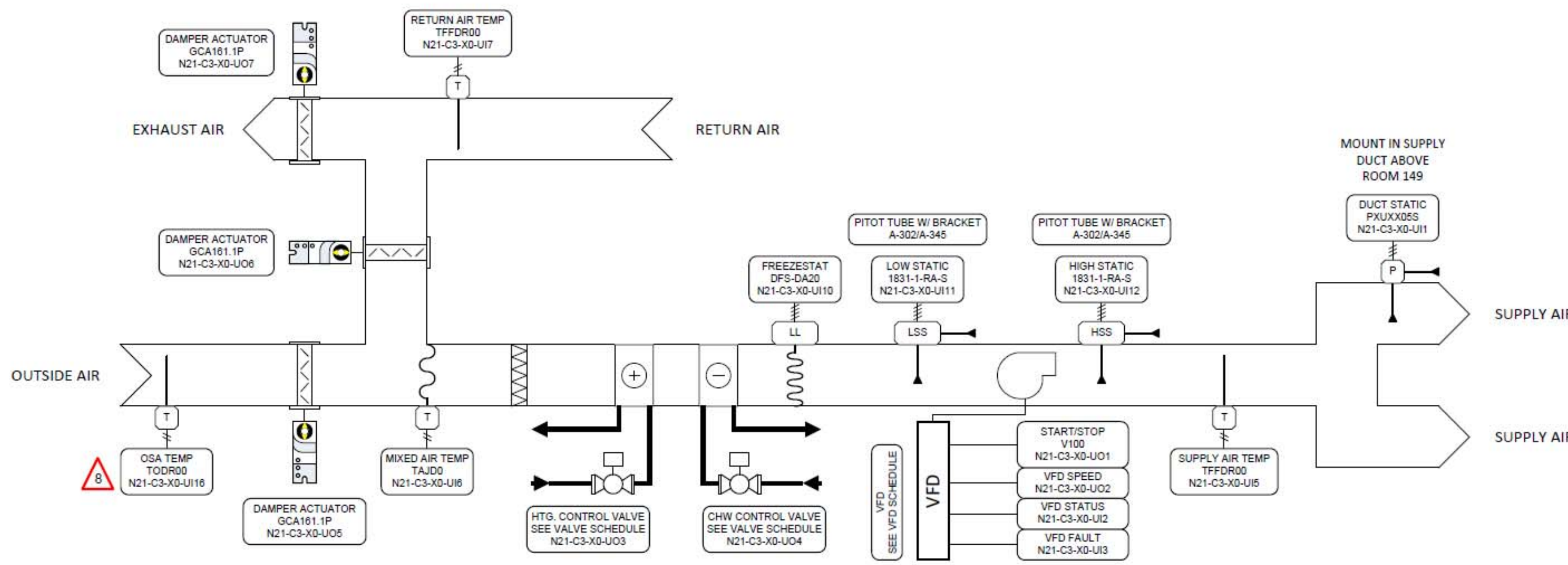

Figure 23. JFHQ Typical Control Schematic Diagram for AHU-1, 2, 3 & 4

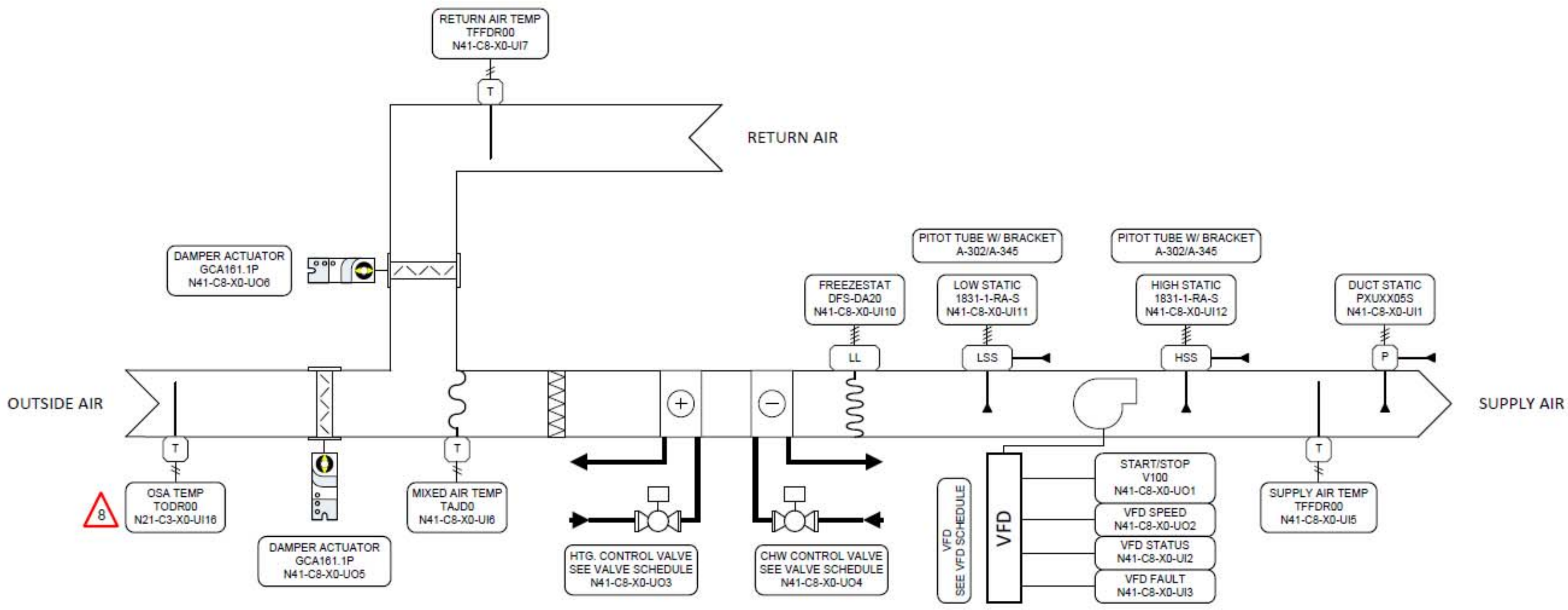

Figure 24. JFHQ Typical Control Schematic Diagram for AHU-9

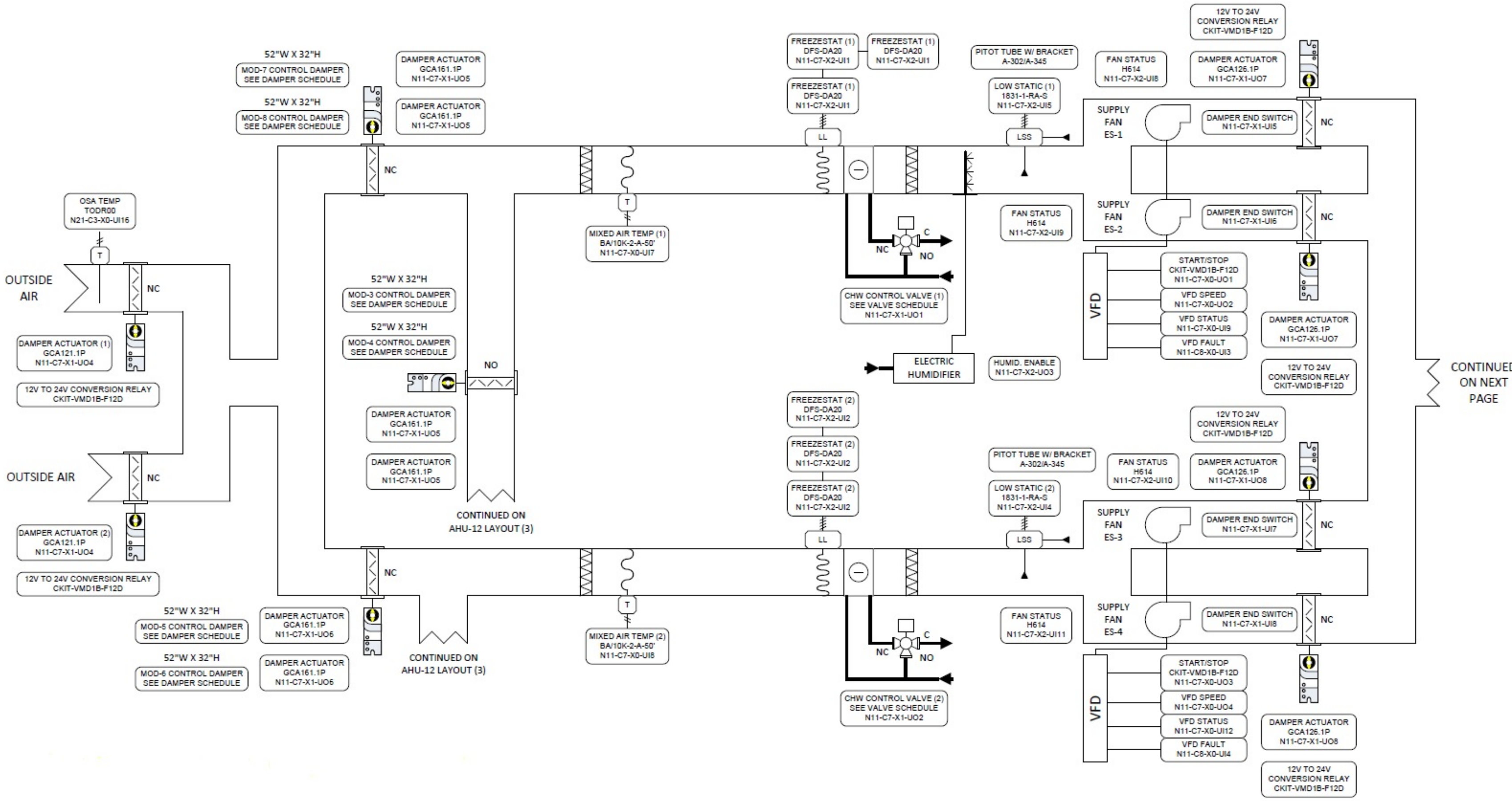

Figure 25. JFHQ Typical Control Schematic Diagram for AHU-12

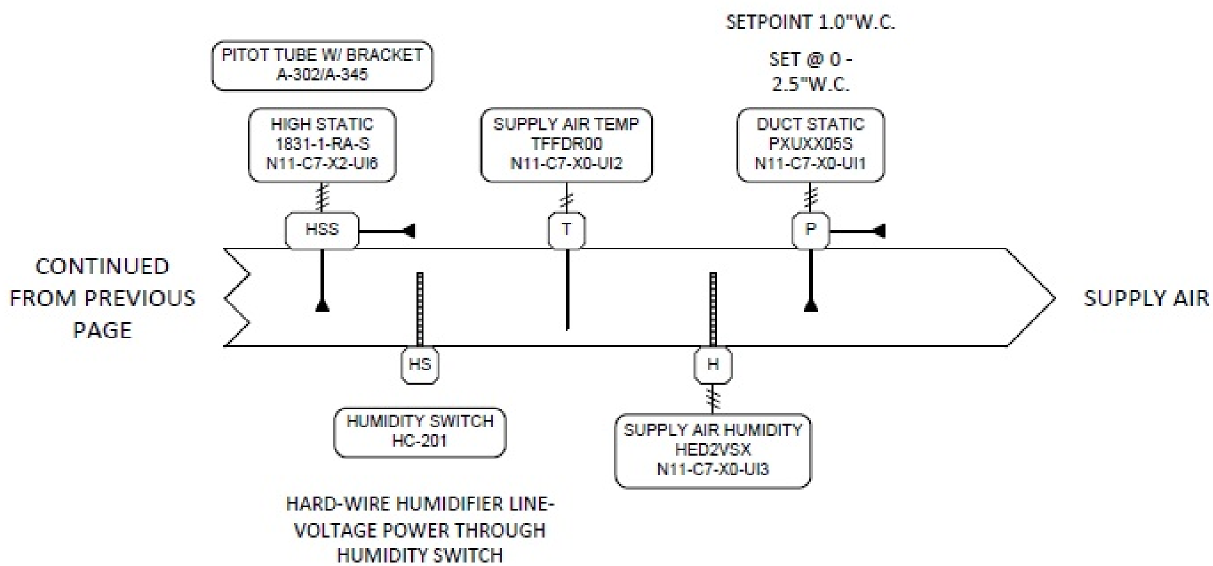

Figure 26. JFHQ Typical Control Schematic Diagram for AHU-12

Site #2 Muscatine Armed Forces Reserve Center (AFRC)

This site's BAS is Johnson Controls' METASYS Building Automation System. Three AAON rooftop units (RTU-1, 3 and 4) with variable-speed control fans and 33 VAV terminal units provide heating and cooling for the building. RTU 3 and 4 are similar in size and capacity, and RTU-1 is a smaller unit. A typical control schematic diagram for the RTUs is illustrated in Figure 28.

The VFD for the RTU supply and exhaust fans comes with the equipment. The VFD models (YASKAWA V1000 and J1000) were too old and did not have the capability to be integrated into the existing BAS via digital communication. IEC staff installed HOBO U30 data loggers and their compatible watt transducers inside the RTU to record fan power data (including VFD) independent of the building control system. Figure 27 shows a picture of the VFDs. The VFD power data was logged at 1-minute intervals and transmitted to Onset's data server via commercial cellular data communication once every 10 minutes. The data was downloaded remotely for data analysis.

A controls engineer from Johnson Controls local branch office performed customized programming, training, and setup data collections for control method performance evaluation. All of these RTUs were used to test fixed static pressure vs. TTR method.

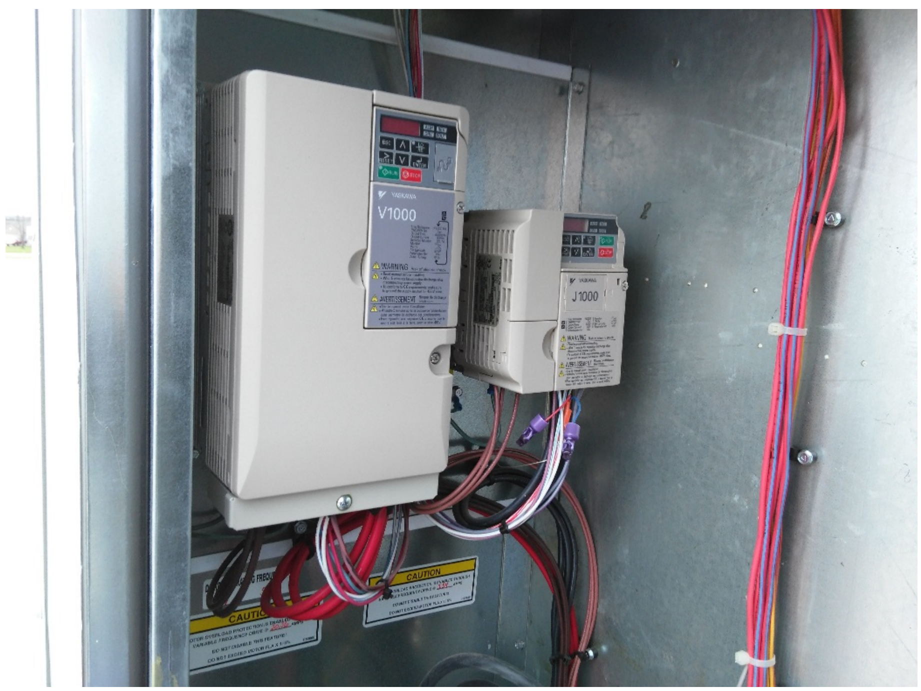

Figure 27. Muscatine AFRC RTU-3 VFDs

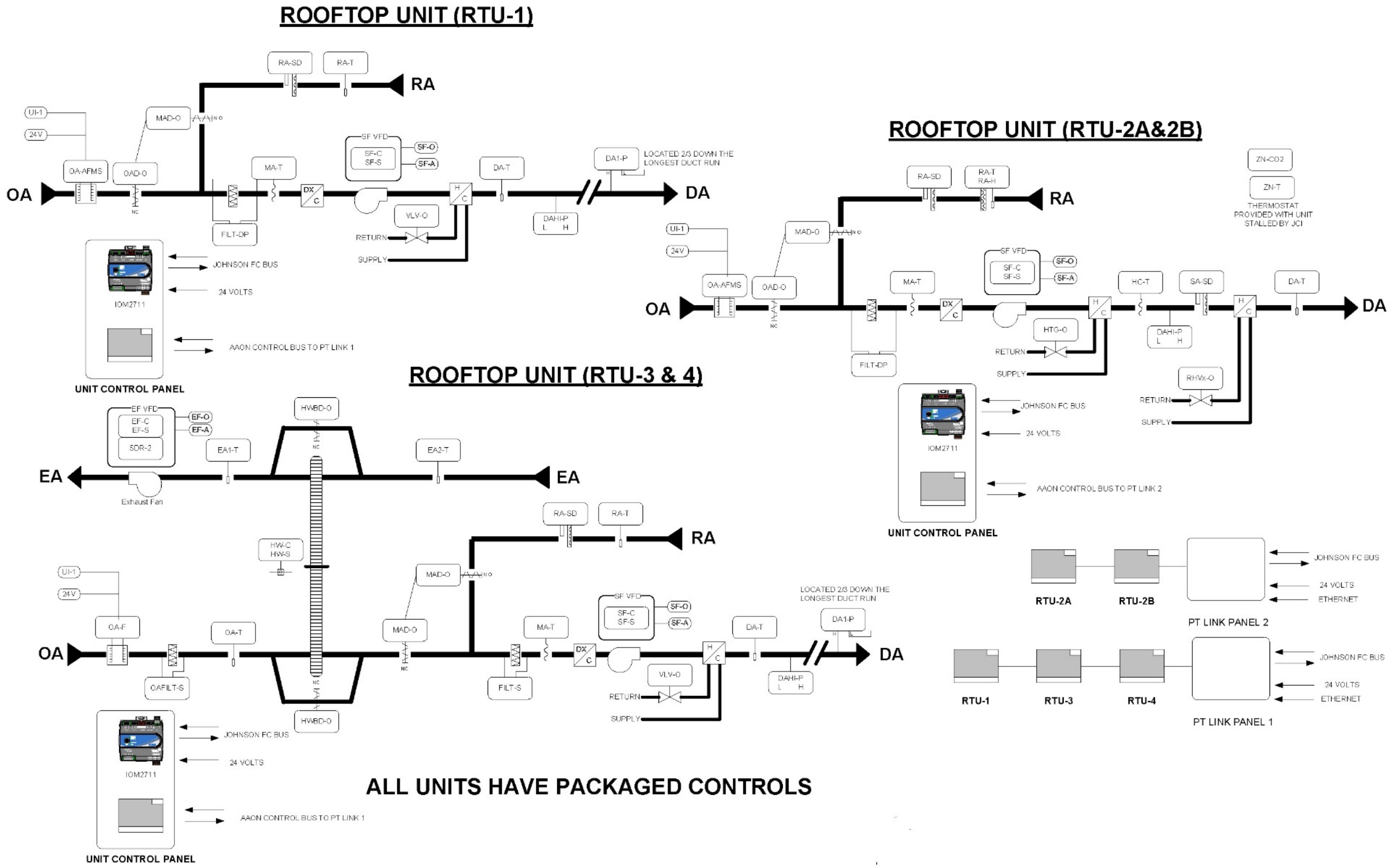

Figure 28. Muscatine AFRC RTU Control Schematic Diagram

Site #3 Waterloo Army Readiness Center (RC)

Similar to the Muscatine site, this site also uses Johnson Controls' METASYS Building Automation System to control the HVAC system. Among the three RTUs for this site, only one AAON rooftop unit (RTU-1) has variable-speed control fans to provide air to 14 VAV terminal units with electric reheat for heating and cooling all the offices in the building. The other two smaller RTUs are constant volume and serve ICN room and dining room. The control schematic diagram for RTU-1 is similar to Muscatine RTUs.

Similar to the Muscatine RTUs, the two VFDs for RTU-1 supply and exhaust fans come with the equipment. The VFD models (both YASKAWA GPD 315/V7) were too old and did not have the capability to be integrated into the existing BAS via digital communication. The exhaust fan VFD for RTU-1 was found to be bad during the first site visit. There was also no static pressure reset in place for RTU-1. Later, this VFD was replaced with a newer model YASKAWA J1000). HOBO U30 data loggers and their compatible watt transducers were installed inside the RTU by IEC staff to record fan power data. Figure 29 shows a picture of these VFDs with HOBO U30 data logger, current transducers, and watt transducers installed. The VFD power data was logged at 1-minute intervals and transmitted to Onset's data server via commercial cellular data communication once every 10 minutes. The data was downloaded remotely for data analysis. RTU-1 was used to test fixed static pressure vs. TTR method. A local Johnson Control branch control engineer performed customized programming, training, and setup data collections for control method performance evaluation.

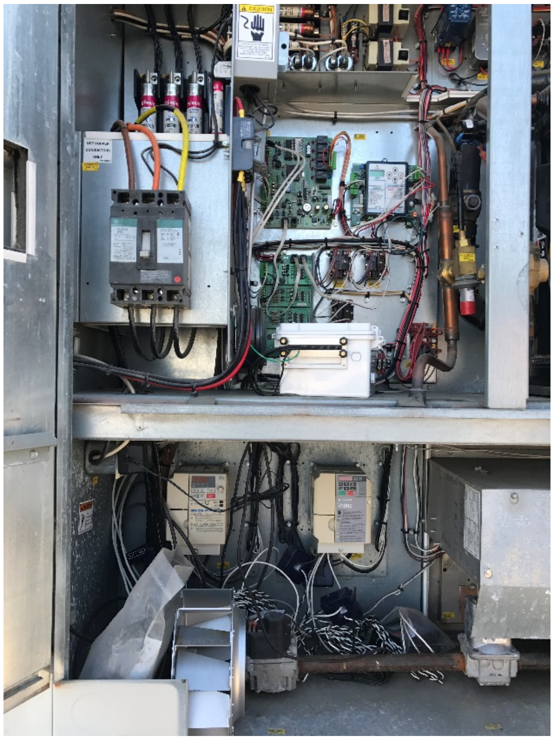

Figure 29. Waterloo RC RTU-1 VFDs and Data Logger

Site #4 Boone Readiness Center (RC)

This site's BAS is Trane's Tracer Summit system. This control system was initially installed and commissioned in 2005. Boone RC has three AHUs, but only two Trane AHUs (AHU-1, 2) are variable-air-volume systems. They provide conditioned air through 66 VAV terminal units. AHU-3 is a constant volume, packaged unit and was not included in this study. AHU-2 control schematic diagram is illustrated in Figure 31. AHU-1 has a similar configuration. Among the four supply and return fan VFDs for AHU-1 and AHU-2, three of them are the Trane TR200 model, and the fourth is Square D's Econoflex model. Trane TR200 was easily integrated into the existing Trane Tracer Summit building control system to record VFD output power by adding BACnet option modules on the VFDs. A separate energy monitoring meter was added and integrated into the existing BAS system to record AHU-1 return fan VFD's power readings.

Figure 30. Boone RC AHU-1 Supply Fan VFD

At the first site visit, the mechanical and control systems were found to be in poor condition. Some VAV boxes needed to be recalibrated and heating/cooling parameters adjusted; some fire dampers were closed, preventing AHU supply air to be provided to certain zones; and AHUs' outside air damper and economizer sensors were not working. A local Trane branch control engineer fixed the issues, performed customized programming, training, and setup data collections for control method performance evaluation. Both AHUs were used to test fixed static pressure vs. TTR method.

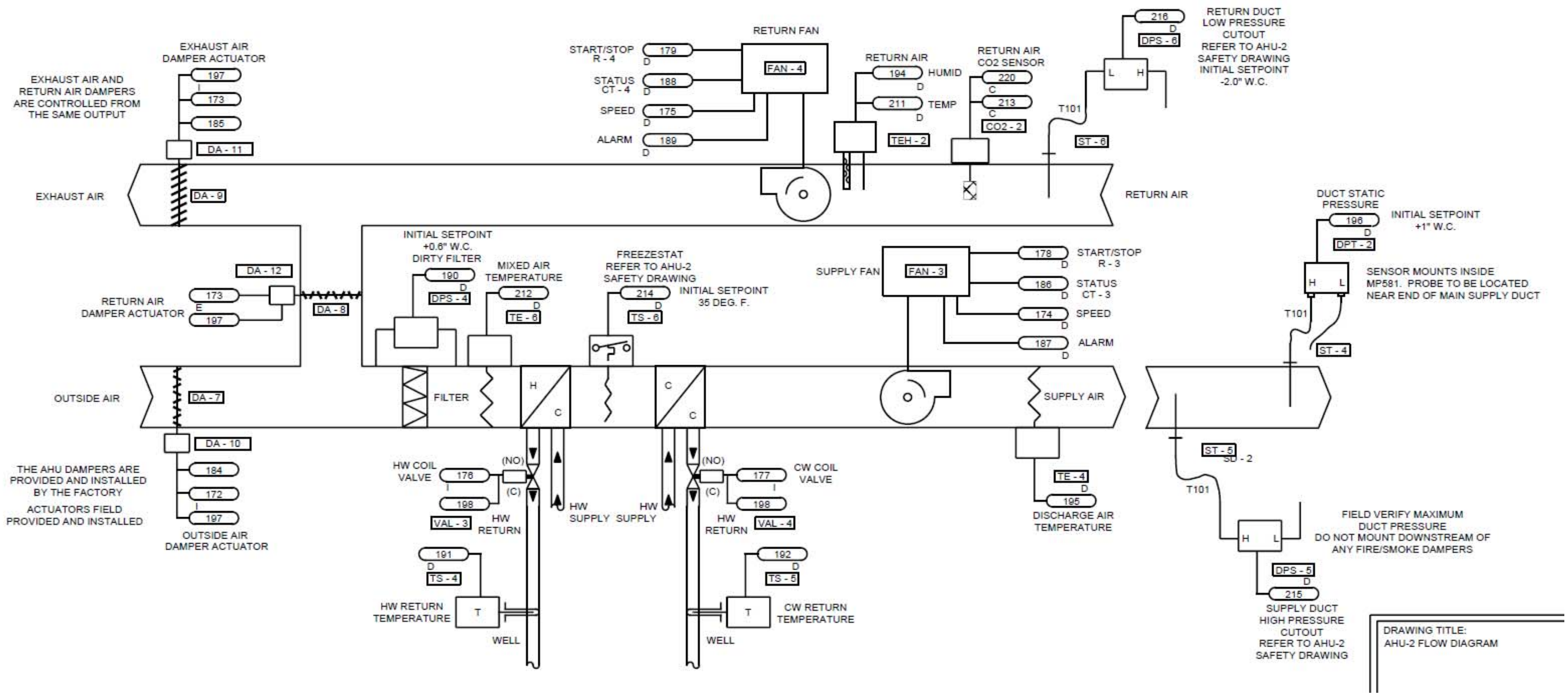

Figure 31. Boone RC AHU-2 Control Schematic Diagram

Site #5 Des Moines Military Entrance Processing Station (MEPS)

This site's BAS is Schneider Electric/TAC/Invensys's I/A series, installed in 2007. One Trane AHU and 34 VAV terminal units are used to provide heating and cooling for this building. The unit has both heating and cooling coils as well as a humidifier. Between the outside air duct and exhaust air duct, there is an energy recovery unit (ERV) that recovers heat from the building. A control schematic of the AHU is illustrated in Figure 33.

The supply and return fan VFDs are ABB ACH550 model (Figure 32) and have the capability to be integrated into the existing BAS system by adding optional BACnet or LonWorks communication card for trending VFD power data. Based on the control design documents, this AHU's supply air temperature and static pressure were reset based on an average of the VAV terminal unit cooling control PID output between 50~60 Deg F and 0.8~1.5 inch WC, respectively.

A local authorized control contractor performed customized programming on the AHU controller and setup initial data collections on the control system server (for multiple buildings). However, during the demonstration, there were problems with network security issues, and the desired data collection for this project could not be continued at the control system server. A new building control data discovering and collection device (Building Robotics Trendr box) was purchased and installed to record and trend fan energy use and relevant HVAC control and monitoring data.

Figure 32. MEPS AHU-1 Return Fan VFD

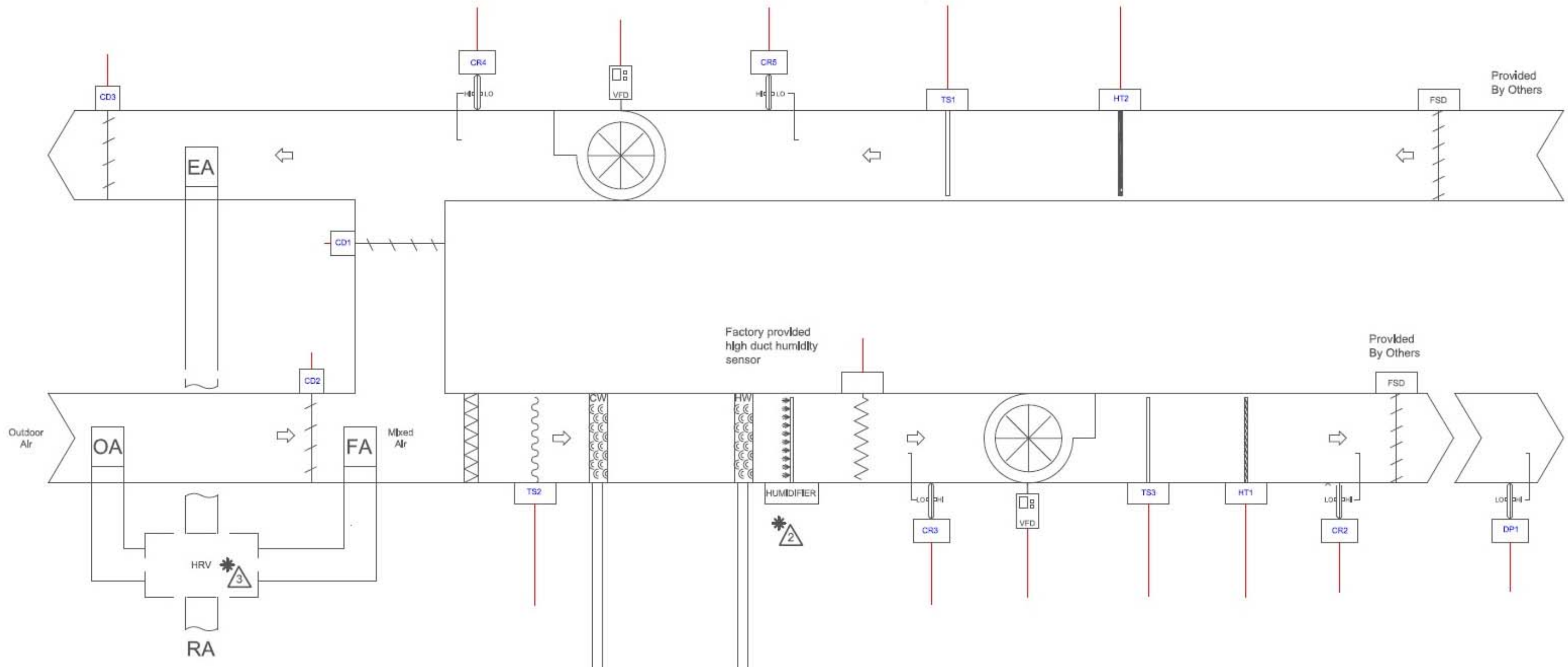

Figure 33. MEPS AHU-1 Control Schematic Diagram

System Integration:

System integration was done by an authorized control system vendor for each site. TTR algorithm control sequences with programming examples and functional test forms (Appendices B and D) were prepared by the research team and made available to control system vendors. The research team worked with the control programmers resolving any questions they had during the software customization. After the software customization was completed, TTR functions were tested and functional test forms filled out by the control programmers and reviewed by the research team to make sure TTR algorithms were implemented correctly. The customized TTR method co-existed with existing control methods (either fixed static pressure control or existing pressure reset). However, only one method was active at any given time during the demonstration period. There was no physical change to the HVAC system; the only change was control methods being switched once every two weeks. On some VFDs, HOBO U30 data logger and watt transducers were installed to record fan power readings.

5.4 OPERATIONAL TESTING

Operational Testing of Cost and Performance:

There were two stages in TTR method implementation: 1) Task 4 software customization and 2) Task 5 system demonstration. In Task 5, before the official demonstration period started, a few months were taken for system startup and commissioning.

System startup and commissioning were completed by local control contractors who were trained and authorized to perform control program customization on the existing building control systems. The team developed functional test scripts covering various operating conditions (including extreme conditions), and data for appropriate monitoring and control points were collected and reviewed to make sure the TTR method was correctly implemented. The potential of a rogue zone problem (a zone controlled by a VAV terminal unit with a damper position that is driving the reset strategy a disproportionately large amount of the time) was mitigated during this phase by troubleshooting and conducting a small-scale retrofit on existing HVAC and control systems.

The cost for the control contractors to perform program customization, troubleshoot and debug, add long-term trends for the points of interest, install and configure software for storing and converting HVAC raw data, were collected for cost analysis.

During the official demonstration period, the TTR program and parameters were kept the same. Relevant building HVAC and control system data and AHU fan energy data were continuously recorded for both baseline periods and demonstration periods to study energy savings and control methods stability performance comparisons. Iowa Army National Guard facility engineers collected the HVAC data locally and sent it to the research team once every two weeks for demonstration monitoring and data analysis.

Timeline:

Figure 34 shows the overall timeline for Task 4, 5, 6, and 7 that are related to demonstration and data analysis. The official demonstration period started in July/August 2015, with several months before that for system troubleshooting and preliminary testing.

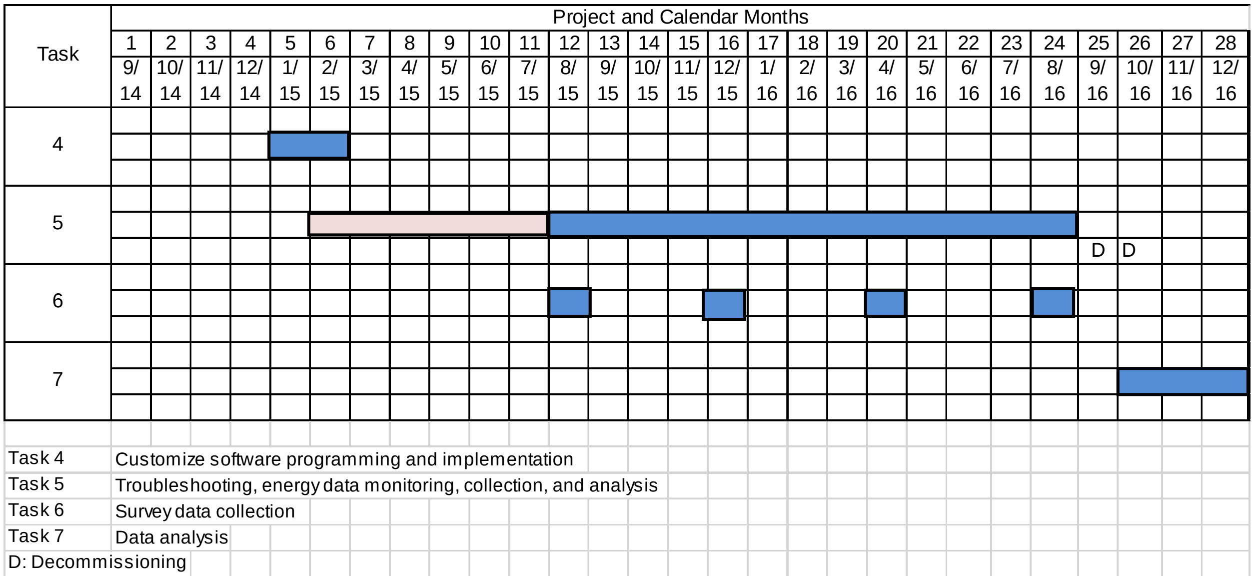

Figure 34. Demonstration Timeline

5.5 SAMPLING PROTOCOL

<u>Data Recording and Data Collectors</u>:

During the one-year demonstration period, AHU/RTU fan energy data for Muscatine AFRC, Waterloo RC, Des Moines MEPS, and one of the six AHUs at JFHQ were recorded automatically by Onset HOBO data loggers at a minimum of every 15 minutes per sample. These data were collected remotely by Iowa Energy Center project team members.

HVAC and controls data were collected by BAS at 1 or 2-minute intervals and processed and converted to a readable format automatically by separate software programs. These data were collected locally by Iowa Army National Guard facility engineers.

Each building meter is equipped with onboard I/O capabilities and 800 kB storage space to store building electric energy use and can be accessed remotely by the Iowa Army National Guard state energy manager. Building meters were configured to log energy consumption at 15-minute intervals.

<u>Data Description</u>:

All HVAC data collected have been converted to ASCII text format or Microsoft Excel spreadsheet compatible format. Different demonstration sites may have different HVAC data formats. The data format for HOBO U30 data logger to record supply and return fan power readings at various sites are the same. Figures 35~40 show HOBO U30 data logger data format and sample HVAC data and building meter formats at five demonstration sites.

Line#	Date	Power (S-UCC 10687354:10629527-1), kW, JFHQ AHU-2 Supply Fan
1	05/15/15 16:11:00	1.9043772
2	05/15/15 16:12:00	1.9043772
3	05/15/15 16:13:00	1.9043772
4	05/15/15 16:14:00	1.9043772
5	05/15/15 16:15:00	1.9043772
6	05/15/15 16:16:00	1.9043772
7	05/15/15 16:17:00	1.9043772
8	05/15/15 16:18:00	1.9043772
9	05/15/15 16:19:00	1.731252
10	05/15/15 16:20:00	1.9043772
11	05/15/15 16:21:00	1.9043772
12	05/15/15 16:22:00	1.9043772
13	05/15/15 16:23:00	1.9043772
14	05/15/15 16:24:00	1.9043772

Figure 35. Sample Power Data from HOBO U30 Data Logger

Timestamp	CD_JFHQ_BOS_2_AHU_1$2c$20AS_Press	CD_JFHQ_BOS_2_AHU_1$2c$20ASSP_PRESS_EFFECTIVE	CD_JFHQ_BOS_2_AHU_1_ASSP_TTRC_EFFECTIVE	CD_JFHQ_BOS_2_AHU_1_MAX_MDP	CD_JFHQ_BOS_2_AHU_1$2c$20Supply_Fan_Speed	CD_JFHQ_BOS_2_AHU$2d1_SF_VFD$2c$20KWH$20$28R$29	CD_JFHQ_BOS_2_AHU$2d1_SF_VFD$2c$20POWER	CD_JFHQ_BOS_2_AHU_1$2c$20ASSP_TEMP_EFFECTIVE	CD_JFHQ_BOS_2_AHU_1$2c$20AS_Temp	CD_JFHQ_BOS_2_points$2c$20ADV_TTRC_Enable
7/10/2016 6:23	1.46	1.5	1.5	100	97.18	60690	11.2	55	60.05	FALSE
7/10/2016 6:24	1.45	1.5	1.5	100	97.19	60691	11.3	55	59.9	FALSE
7/10/2016 6:25	1.46	1.5	1.5	100	97.19	60691	11.2	55	59.52	FALSE
7/10/2016 6:26	1.44	1.5	1.5	100	97.6	60691	11.4	55	58.82	FALSE
7/10/2016 6:27	1.43	1.5	1.5	100	98.18	60691	11.8	55	58.4	FALSE
7/10/2016 6:28	1.49	1.5	1.5	100	97.95	60691	11.7	55	58.22	FALSE
7/10/2016 6:29	1.51	1.5	1.5	100	97.95	60692	11.5	55	57.87	FALSE
7/10/2016 6:30	1.51	1.5	1.5	100	97.95	60692	11.6	55	57.55	FALSE
7/10/2016 6:31	1.53	1.5	1.5	100	97.95	60692	11.5	55	57.28	FALSE
7/10/2016 6:32	1.56	1.5	1.5	100	97.82	60692	11.5	55	56.84	FALSE
7/10/2016 6:33	1.56	1.5	1.5	100	97.82	60692	11.5	55	56.84	FALSE
7/10/2016 6:33	1.56	1.5	1.5	100	97.44	60693	11.3	55	56.45	FALSE
7/10/2016 6:34	1.55	1.5	1.5	100	97.51	60693	11.4	55	56.13	FALSE
7/10/2016 6:35	1.55	1.5	1.5	100	97.33	60693	11.3	55	55.87	FALSE
7/10/2016 6:36	1.56	1.5	1.5	100	96.82	60693	11.2	55	55.67	FALSE
7/10/2016 6:37	1.55	1.5	1.5	100	96.5	60693	11	55	55.31	FALSE

Figure 36. Sample HVAC Data from Distech Controls' EC-Net System

time	/182/CO1/Duct Static	/182/CO1/Duct Static:Type	/182/CO1/Duct Static_SP	/182/CO1/OAD	/182/CO1/RAD	/182/CO1/RAT	/182/CO1/RF_SPD	/182/CO1/SAT	/182/CO1/SAT_SP
9/25/2016 14:34	1.31	5.00	1.40	100.00	0.00	75.22	85.00	59.09	57.82
9/25/2016 14:35	1.44	5.00	1.40	100.00	0.00	75.14	85.00	59.01	58.02
9/25/2016 14:36	1.55	5.00	1.40	100.00	0.00	75.03	84.25	58.91	58.17
9/25/2016 14:37	1.61	5.00	1.40	100.00	0.00	74.93	83.24	58.75	58.27
9/25/2016 14:38	1.63	5.00	1.40	100.00	0.00	74.84	82.40	58.62	58.40
9/25/2016 14:39	1.62	5.00	1.40	100.00	1.21	74.78	81.73	58.47	58.49
9/25/2016 14:40	1.59	5.00	1.40	100.00	0.00	74.73	81.20	58.30	58.59
9/25/2016 14:41	1.60	5.00	1.40	100.00	0.00	74.61	80.49	58.18	58.64
9/25/2016 14:42	1.62	5.00	1.40	100.00	0.00	74.53	79.66	58.11	58.71
9/25/2016 14:43	1.59	5.00	1.40	100.00	0.00	74.45	79.18	58.08	58.80
9/25/2016 14:44	1.58	5.00	1.40	100.00	0.00	74.35	78.63	58.04	58.86
9/25/2016 14:45	1.59	5.00	1.40	100.00	0.00	74.33	77.95	58.02	58.93
9/25/2016 14:46	1.57	5.00	1.40	100.00	0.00	74.25	77.51	58.03	58.97
9/25/2016 14:47	1.55	5.00	1.40	100.00	0.00	74.16	77.11	58.03	59.03
9/25/2016 14:48	1.58	5.00	1.40	100.00	0.00	74.13	76.37	58.06	59.11
9/25/2016 14:49	1.57	5.00	1.40	100.00	0.00	74.04	75.89	58.06	59.16
9/25/2016 14:50	1.55	5.00	1.40	100.00	0.00	73.95	75.50	58.06	59.20
9/25/2016 14:51	1.57	5.00	1.40	100.00	0.00	73.94	74.83	58.09	59.33
9/25/2016 14:52	1.56	5.00	1.40	100.00	0.00	73.87	74.35	58.14	59.38
9/25/2016 14:53	1.55	5.00	1.40	100.00	0.00	73.82	73.92	58.19	59.43
9/25/2016 14:54	1.55	5.00	1.40	100.00	0.00	73.80	73.40	58.19	59.53
9/25/2016 14:55	1.54	5.00	1.40	100.00	0.00	73.79	73.00	58.17	59.55
9/25/2016 14:56	1.53	5.00	1.40	100.00	0.00	73.73	72.58	58.28	59.63
9/25/2016 14:57	1.52	5.00	1.40	100.00	0.00	73.66	72.23	58.30	59.66
9/25/2016 14:58	1.54	5.00	1.40	100.00	0.00	73.65	71.64	58.40	59.77
9/25/2016 14:59	1.51	5.00	1.40	100.00	0.00	73.60	71.48	58.49	59.76
9/25/2016 15:00	1.51	5.00	1.40	100.00	0.00	73.58	71.09	58.47	59.77
9/25/2016 15:01	1.51	5.00	1.40	100.00	0.00	73.53	70.72	58.53	59.85
9/25/2016 15:02	1.52	5.00	1.40	100.00	0.00	73.50	70.28	58.59	59.88
9/25/2016 15:03	1.51	5.00	1.40	100.00	0.00	73.43	70.01	58.82	59.90

Figure 37. Sample HVAC Data from TAC/Invensys' IA Series System

Date / Time	Name Path Reference	Object Value
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA12.READINESS.VA12.DPR-O.120secPresent Value (Trend2)	66.26919
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA13.READINESS.VA13.ZN-T.120secPresent Value (Trend2)	72.01307
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA13.READINESS.VA13.EFFHTG-SP.120secPresent Value (Trend1)	70
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA13.READINESS.VA13.EFFCLG-SP.120secPresent Value (Trend1)	74
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA13.READINESS.VA13.DPR-O.120secPresent Value (Trend2)	41.38661
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA14.READINESS.VA14.ZN-T.120secPresent Value (Trend2)	73.79585
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA14.READINESS.VA14.EFFHTG-SP.120secPresent Value (Trend1)	70
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA14.READINESS.VA14.EFFCLG-SP.120secPresent Value (Trend1)	74
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.VA14.READINESS.VA14.DPR-O.120secPresent Value (Trend2)	35.61969
9/11/2015 13:08	GuardReadiness:S1-NAE02/Programming.RTU-1.DuctPresReset.RTU-1_TTR-SP.120secPresent Value (Trend2)	0.53
9/11/2015 13:08	GuardReadiness:S1-NAE02/Programming.RTU-1.DuctPresReset.RTU-1_MAX.120secPresent Value (Trend2)	84.53323
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.RTUS.Analog Inputs.S_Vcm[000].VfdExPos.Present Value (Trend1)	0
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.RTUS.Analog Inputs.S_Vcm[000].SaTp.Present Value (Trend1)	70.2
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.RTUS.Analog Outputs.S_Vcm[000].SaHtSt.Present Value (Trend1)	65
9/11/2015 13:08	GuardReadiness:S1-NAE02/FC-A.RTUS.Analog Outputs.S_Vcm[000].SaClSt.Present Value (Trend1)	65
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA7.READINESS.VA7.EFFHTG-SP.120secPresent Value (Trend1)	70
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA7.READINESS.VA7.EFFCLG-SP.120secPresent Value (Trend1)	74
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA7.READINESS.VA7.DPR-O.120secPresent Value (Trend2)	28.65803
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA8.READINESS.VA8.ZN-T.120secPresent Value (Trend2)	73.65174
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA8.READINESS.VA8.EFFHTG-SP.120secPresent Value (Trend1)	70
9/11/2015 13:06	GuardReadiness:S1-NAE02/FC-A.VA8.READINESS.VA8.EFFCLG-SP.120secPresent Value (Trend1)	74

Figure 38. Sample HVAC Data from Johnson Controls' METASYS System

DateTimeStamp	AHU1 Supply DuctPressure	AHU1 Supply Duct Static Stpt	AHU1 SupplyVFD Drv Pwr	AHU1 ReturnFan VFD Power	Enable AHU1 Trim and Response	AHU2 Supply DuctPressure	AHU2 Supply Duct Static Stpt	AHU2 SupplyVFD Drv Pwr	AHU2 ReturnVFD Drv Pwr	Enable AHU2 Trim and Response
06/07/16 08:52 AM	2.19591	2.2	2.9	3.47912	0	1.6941	1.7	3.8	2.7	0
06/07/16 08:53 AM	2.18386	2.2	2.7	3.5135	0	1.6941	1.7	3.7	2.6	0
06/07/16 08:54 AM	2.18386	2.2	2.8	3.54719	0	1.69811	1.7	3.8	2.6	0
06/07/16 08:55 AM	2.18386	2.2	2.7	3.57344	0	1.69811	1.7	3.9	3.3	0
06/07/16 08:56 AM	2.1678	2.2	3	3.53006	0	1.69811	1.7	3.8	2.9	0
06/07/16 08:57 AM	2.20393	2.2	2.9	3.49086	0	1.69811	1.7	3.7	3.2	0
06/07/16 08:58 AM	2.20393	2.2	2.9	3.57372	0	1.69811	1.7	3.9	2.7	0
06/07/16 08:59 AM	2.21196	2.2	2.8	3.49073	0	1.69811	1.7	3.9	2.6	0
06/07/16 09:00 AM	2.20393	2.2	2.9	3.56889	0	1.69811	1.7	3.7	3.2	0
06/07/16 09:01 AM	2.17985	2.2	2.9	3.54323	0	1.69811	1.7	4	3	0
06/07/16 09:02 AM	2.20795	2.2	2.7	3.56795	0	1.69811	1.7	3.8	2.8	0
06/07/16 09:03 AM	2.15175	2.2	2.4	3.30627	0	1.69811	1.7	3.7	2.9	0
06/07/16 09:04 AM	2.19992	2.2	2.7	3.52835	0	1.69008	1.7	3.7	2.9	1
06/07/16 09:05 AM	2.15576	2.2	2.8	3.56699	1	1.56965	1.1	3.2	2.4	1
06/07/16 09:06 AM	2.19992	1.6	2.2	2.92456	1	1.43316	1	3.1	1.9	1
06/07/16 09:07 AM	1.82256	1	2.2	2.97605	1	1.32477	1	2.8	1.7	1
06/07/16 09:08 AM	1.7503	1	1.6	2.39351	1	1.23244	1	2.6	2.1	1
06/07/16 09:09 AM	1.25251	1	1.5	2.37072	1	1.20032	1	2.6	1.9	1
06/07/16 09:10 AM	1.14412	1	1.2	2.19888	1	1.12405	1	2.8	1.9	1
06/07/16 09:11 AM	1.0558	1	1.3	2.15411	1	1.12405	1.3	2.6	1.8	1
06/07/16 09:12 AM	1.06383	1.3	1.3	2.04918	1	1.1401	1.7	2.8	1.9	1
06/07/16 09:13 AM	1.15215	1.9	1.5	2.31069	1	1.25652	1.7	3.3	2.3	1
06/07/16 09:14 AM	1.48936	1.9	2.1	2.86155	1	1.3047	1.7	3.8	2.8	1
06/07/16 09:15 AM	1.6379	1.3	2.2	2.99632	1	1.41309	1.7	3.7	2.7	1
06/07/16 09:16 AM	1.46527	1	1.9	2.66648	1	1.48535	1.7	4.3	3	1
06/07/16 09:17 AM	1.26857	1	1.5	2.39568	1	1.53352	1.7	4	2.9	1
06/07/16 09:18 AM	1.19631	1	1.4	2.24832	1	1.62585	1.1	3.8	2.6	1
06/07/16 09:19 AM	1.11602	1	1.3	2.10219	1	1.65395	1.1	3.4	2.4	1

Figure 39. Sample HVAC Data from Trane's Tracer Summit System

CAMP_DODGE.JFHQ_BUILDING_MAIN	
8/22/16 9:30 AM	70,882,421.78
8/22/16 9:15 AM	70,882,241.67
8/22/16 9:00 AM	70,882,056.13
8/22/16 8:45 AM	70,881,877.59
8/22/16 8:30 AM	70,881,698.57
8/22/16 8:15 AM	70,881,520.02
8/22/16 8:00 AM	70,881,343.18
8/22/16 7:45 AM	70,881,161.13
8/22/16 7:30 AM	70,881,004.26
8/22/16 7:15 AM	70,880,873.14
8/22/16 7:00 AM	70,880,743.57
8/22/16 6:45 AM	70,880,614.46
8/22/16 6:30 AM	70,880,491.50
8/22/16 6:15 AM	70,880,366.23

Figure 40. Sample Data from Building Meter at JFHQ

Summaries of demonstration data collected for each site are listed in Tables 5~9.

Table 5. Summary of Data Collected for Site #1

	HVAC & Controls Data	HOBO Data	Building Meter Data	Weather Data
Total number of points	1169	2	1	12
Data sampling interval	1 min	1 min	15 min	20 min
Dates data were collected	7/27/2015-9/19/2016	5/1/2015-10/28/2016	8/17/2015-10/15/2016	6/1/2015-10/15/2016

Table 6. Summary of Data Collected for Site #2

	HVAC & Controls Data	HOBO Data	Building Meter Data	Weather Data
Total number of points	36	11	1	12
Data sampling interval	2 min	1 min	15 min	20 min
Dates data were collected	6/26/2015-10/14/2016	5/1/2015-10/28/2016	6/27/2015-9/29/2016	6/1/2015-10/15/2016

Table 7. Summary of Data Collected for Site #3

	HVAC & Controls Data	HOBO Data	Building Meter Data	Weather Data
Total number of points	70	3	1	12
Data sampling interval	2 min	1 min	15 min	20 min
Dates data were collected	6/7/2015-10/11/2016	5/1/2015-10/28/2016	6/7/2015-8/27/2016	6/1/2015-10/15/2016

Table 8. Summary of Data Collected for Site #4

	HVAC & Controls Data	HOBO Data	Building Meter Data	Weather Data
Total number of points	290	-	1	12
Data sampling interval	1 min	-	15 min	20 min
Dates data were collected	7/20/2015-12/31/2016	-	12/8/2015-12/31/2016	6/1/2015-12/31/2016

Table 9. Summary of Data Collected for Site #5

	HVAC & Controls Data	HOBO Data	Building Meter Data	Weather Data
Total number of points	230	-	1	12
Data sampling interval	1 min	-	15 min	20 min
Dates data were collected	7/30/2015-10/08/2016	-	8/7/2015-9/30/2016	6/1/2015-10/15/2016

Besides technical data collected, all invoices from local building controls contractors were collected for cost analysis and system economics analysis.

Data Storage and Backup

AHU fan energy data for Des Moines MEPS, Muscatine AFRC and Waterloo RC sites were downloaded remotely from Onset's data server and stored at Iowa Energy Center research team's internal data server. AHU fan energy data for other sites and HVAC data at all sites were collected by IAARNG facility engineers and copied on Iowa Energy Center's internal data server. Five sites' building electric meter data were collected by IAARNG state energy manager and copied on Iowa Energy Center's internal data server. Iowa Energy Center's internal data server is backed up daily using two external storage hard drives.

Data Collection Diagram

For AHU fan energy data collection using HOBO U30 energy data logger, a wiring diagram of current transmitter, watt transmitter, and HOBO data logger for measuring one set of AHU/RTU supply and return fan power is shown in Figure 41.

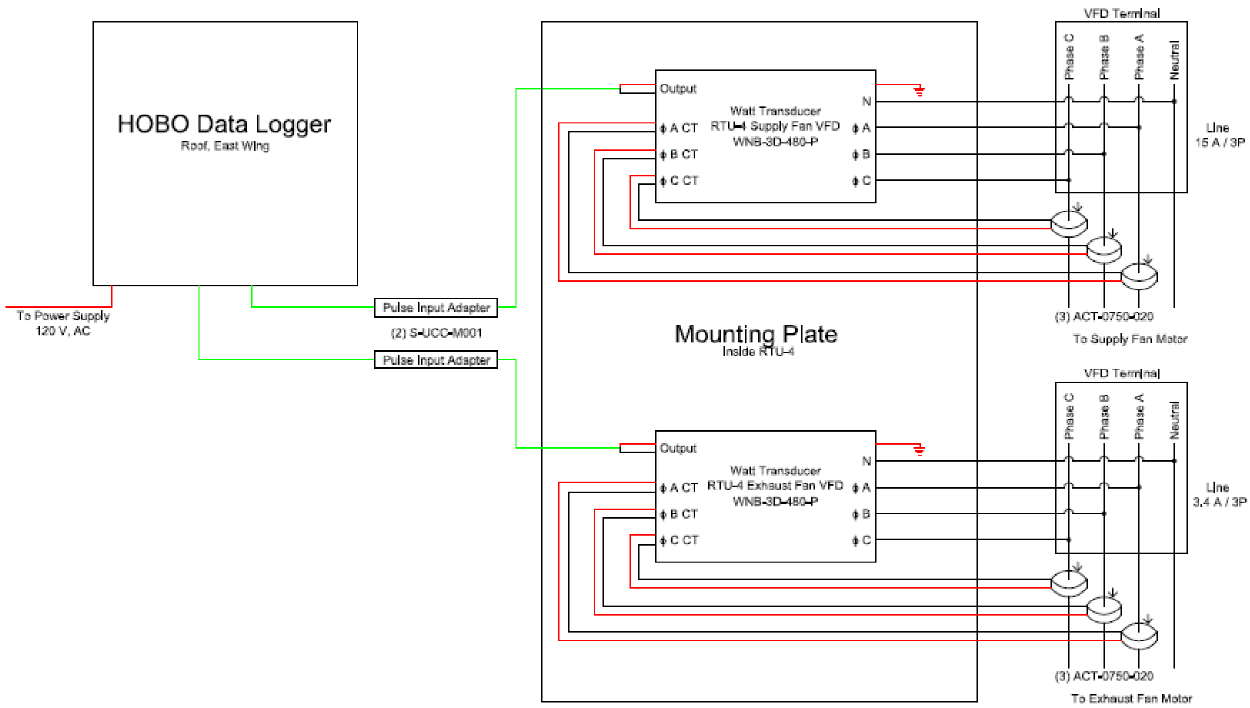

Figure 41. Sample Wiring Diagram Using HOBO U30 Data Logger

The U30 data logger has logging capability with sampling rate from 1 second to 18 hours per sample and local nonvolatile flash data storage of 512K bytes. The cellular network version (GSM or C3G models) can also transmit data through the commercial cellular network (AT&T) to manufacturer's data server for the user to monitor via the internet near real-time and download data at a later time (Figure 43). Figure 42 illustrates a screenshot of a sample energy data monitoring web page using HOBO link.

Figure 42. A Sample Webpage Using HOBO Link

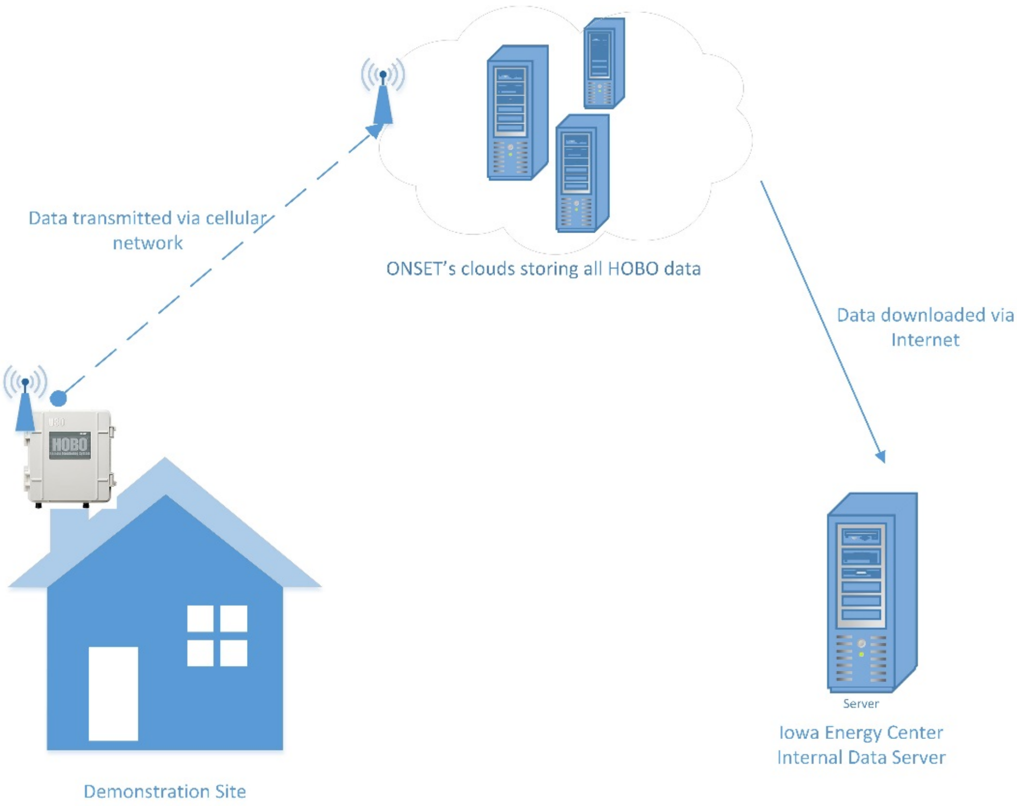

Figure 43. HOBO U30 Data Logger Data Collection Schematic

The building HVAC/control system trended data were not directly readable and were processed using an internal export function or using separate exporting/reporting software tools. They are described in detail below.

Site #1 Joint Forces Headquarters (JFHQ)

The trended HVAC data for the JFHQ building were temporarily stored in several Distech Controls' network controllers called EC-BOS and then copied to a supervisory server for long-term storage. A third-party driver was installed by a local controls contractor to allow him to build a Microsoft Excel spreadsheet program to export the data in .csv format via a web page. By default, the web page allows for downloads of both individual and merged histories for today, yesterday, this month and last month (Figure 45.) IAARNG facility engineer downloaded the data from his desktop weekly and sent it to Iowa Energy Center research team via email or secured FTP site. The data collection diagram is shown in Figure 44.

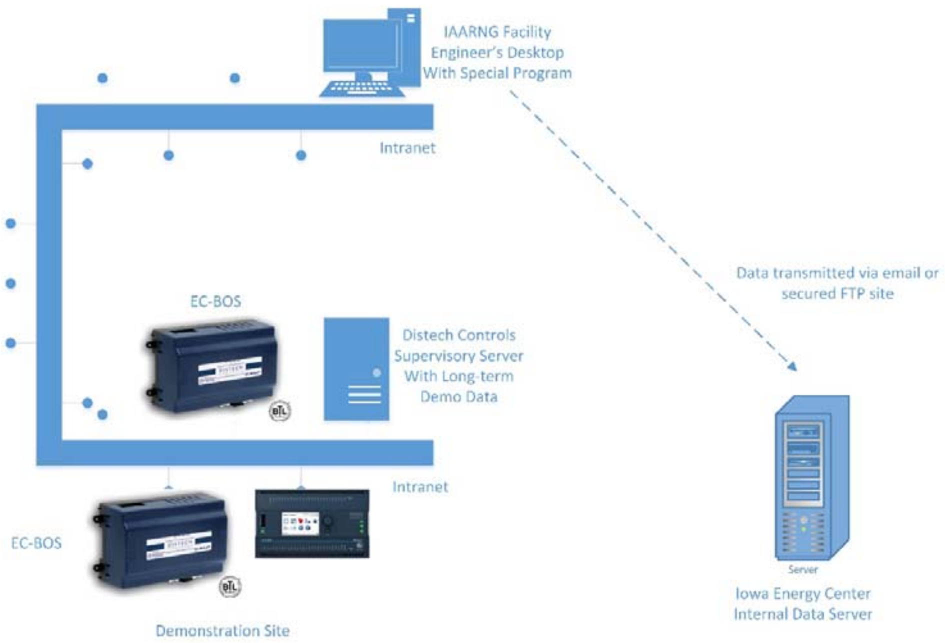

Figure 44. Data Collection Diagram for JFHQ

File	History ID	Today	Yesterday	This Month	Last Month
Merge All		Download	Download	Download	Download
Zip All		Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_118$2c$20Damper_Position_FB.csv	/CD_JFHQ_BOS_4/VAV_118, Damper_Position_FB	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_118$2c$20EFF_Cool_SP.csv	/CD_JFHQ_BOS_4/VAV_118, EFF_Cool_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_118$2c$20EFF_Heat_SP.csv	/CD_JFHQ_BOS_4/VAV_118, EFF_Heat_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_118$2c$20Occupancy_Status.csv	/CD_JFHQ_BOS_4/VAV_118, Occupancy_Status	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_118$2c$20Space_Temp.csv	/CD_JFHQ_BOS_4/VAV_118, Space_Temp	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_120A$2c$20Damper_Position_FB.csv	/CD_JFHQ_BOS_4/VAV_120A, Damper_Position_FB	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_120A$2c$20EFF_Cool_SP.csv	/CD_JFHQ_BOS_4/VAV_120A, EFF_Cool_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_120A$2c$20EFF_Heat_SP.csv	/CD_JFHQ_BOS_4/VAV_120A, EFF_Heat_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_120A$2c$20Occupancy_Status.csv	/CD_JFHQ_BOS_4/VAV_120A, Occupancy_Status	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_120A$2c$20Space_Temp.csv	/CD_JFHQ_BOS_4/VAV_120A, Space_Temp	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_121$2c$20Damper_Position_FB.csv	/CD_JFHQ_BOS_4/VAV_121, Damper_Position_FB	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_121$2c$20EFF_Cool_SP.csv	/CD_JFHQ_BOS_4/VAV_121, EFF_Cool_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_121$2c$20EFF_Heat_SP.csv	/CD_JFHQ_BOS_4/VAV_121, EFF_Heat_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_121$2c$20Occupancy_Status.csv	/CD_JFHQ_BOS_4/VAV_121, Occupancy_Status	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_121$2c$20Space_Temp.csv	/CD_JFHQ_BOS_4/VAV_121, Space_Temp	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_126$2c$20Damper_Position_FB.csv	/CD_JFHQ_BOS_4/VAV_126, Damper_Position_FB	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_126$2c$20EFF_Cool_SP.csv	/CD_JFHQ_BOS_4/VAV_126, EFF_Cool_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_126$2c$20EFF_Heat_SP.csv	/CD_JFHQ_BOS_4/VAV_126, EFF_Heat_SP	Download	Download	Download	Download
CD_JFHQ_BOS_4_VAV_126$2c$20Occupancy_Status.csv	/CD_JFHQ_BOS_4/VAV_126, Occupancy_Status	Download	Download	Download	Download

Figure 45. Export JFHQ Data via a Webpage

Site #2 Muscatine Armed Forces Reserve Center (AFRC)

There was no server for Johnson Controls' Metasys building control system at this site. Therefore, the HVAC/controls data were trended and stored in the Network Automation Engine (NAE) short-term (due to limited storage space available), then overridden with the latest data. Johnson Controls' Metasys Export Utility software was installed by the control contractor and configured to add the capability to extract historical trend data automatically *daily* from the NAE and export the data in a .csv format. An IAARNG facility engineer then copied the CSV files onto a USB drive and delivered it to Iowa Energy Center bi-weekly (Figure 46.)

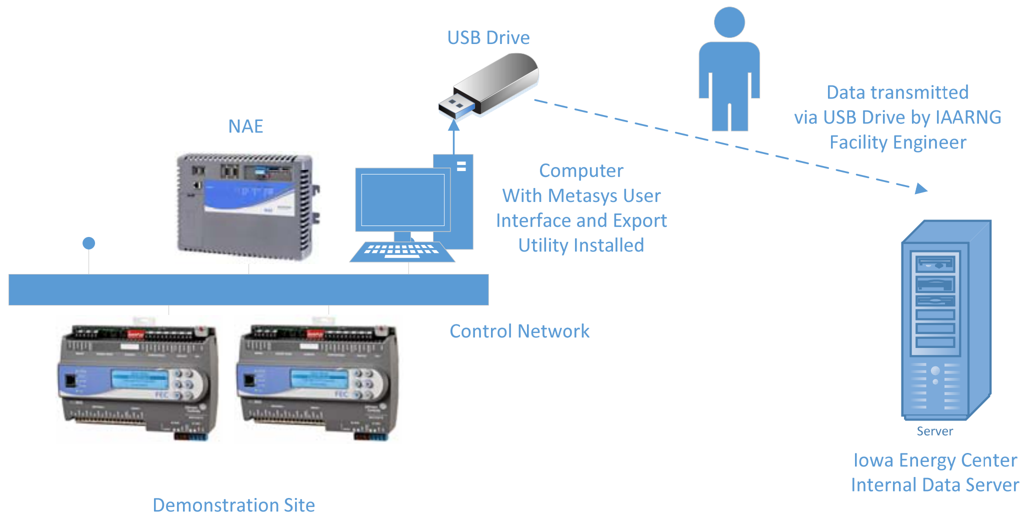

Figure 46. Data Collection Diagram for Muscatine AFRC

Site #3 Waterloo Readiness Center (RC)

Both the Waterloo RC and the Muscatine AFRC sites have the Johnson Controls METASYS extended architecture building control system and are served by the same Johnson Controls local branch (Cedar Rapids office). The data collection process for the Waterloo RC site is the same as the Muscatine AFRC site.

Site #4 Boone Readiness Center (RC)

Trane's Tracer Summit building control system does not have a server to store long-term data at this site, and its building controller unit (BCU) used to store short-term data was not able to trend the demonstration data points at 1 or 2-minute intervals due to limitations with its internal memory. Third-party software, "BACbone Data Analytic," was purchased and installed on a separate laptop connected to the control network to solve the problem. The software can communicate with local BCU and other field controllers via BACnet communication protocol and be configured to collect demonstration data at 1-minute interval and store long-term data on the laptop. The software also has an export function that enabled exportation of the demonstration data in Microsoft Excel spreadsheet format. IAARNG facility engineer or Iowa Energy Center team members regularly went to the site and copied the exported demonstration data to a USB drive and then copied the data to Iowa Energy Center internal data server. The data collection diagram is illustrated in Figure 47.

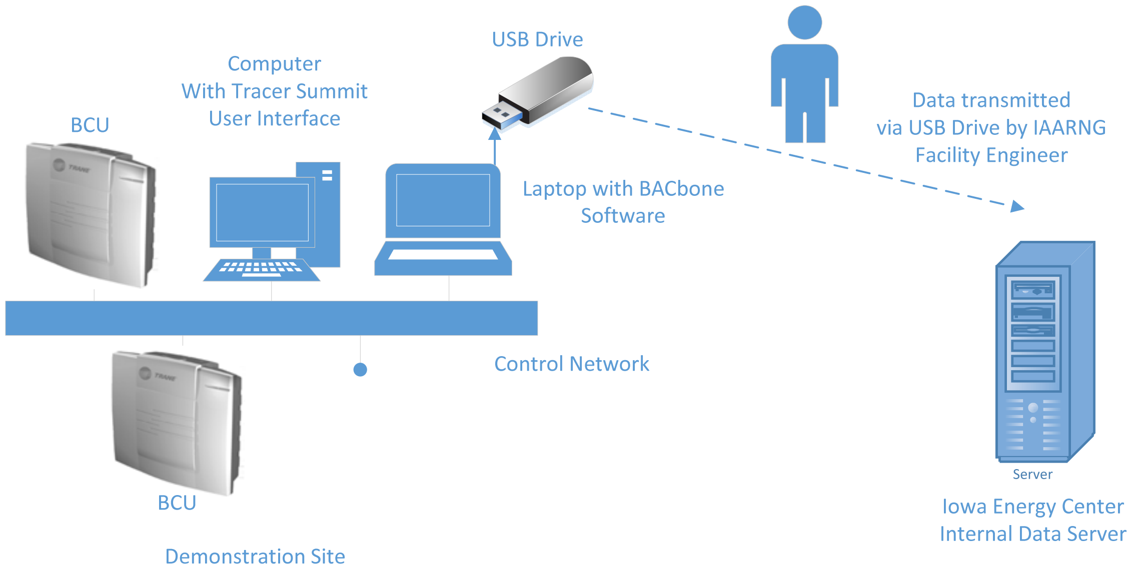

Figure 47. Data Collection Diagram for Boone RC

Site #5 Des Moines Military Entrance Processing Station

This site's building control system is Schneider Electric/TAC/Invensys' I/A series. In the first several months of the demonstration period, the long-term demonstration data for this site were stored in a Schneider Electric/TAC/Invensys control system server for multiple buildings at Camp Dodge, and the data collection scheme was very similar to that of the JFHQ site (Figure 48.)

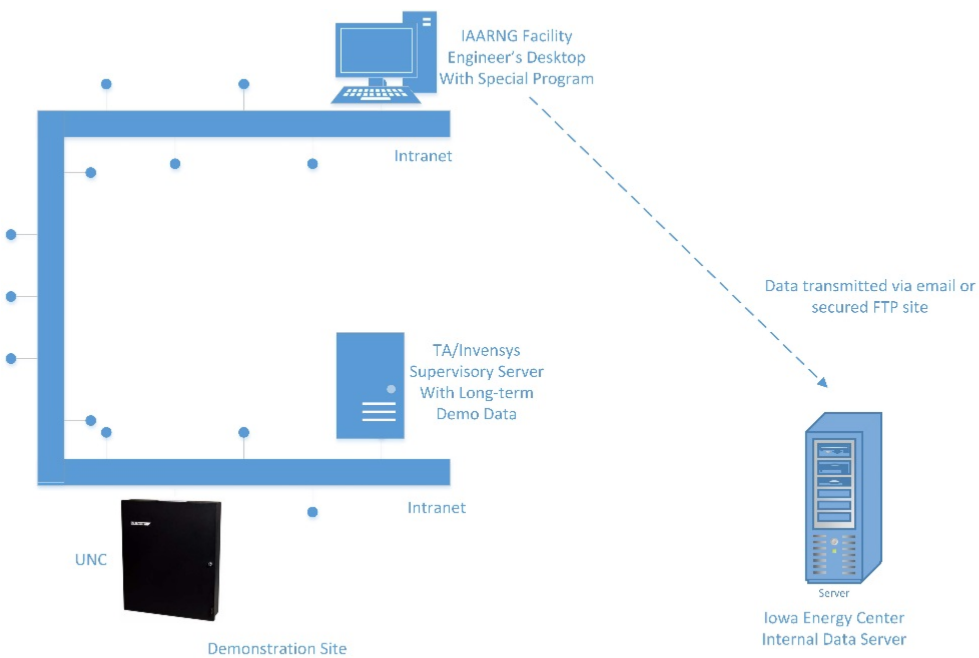

Figure 48. Data Collection Diagram #1 for Des Moines MEPS

However, after several months of project demonstration, the Schneider Electric/TAC/Invensys control system server had a problem and was no longer able to collect long-term demonstration data. A different data collection system was pursued to continue collecting demonstration data. Building Robotics' (now Comfy) TR-1 gateway was purchased and installed on-site and connected to the local building control network. The hardware could directly read BACnet object values in real-time and was configured to transmit 1-minute demonstration data samples to its cloud-based data server via a cellular network. Iowa Energy Center team members remotely downloaded demonstration data from Building Robotics' cloud-based data server via web-based Trendr interface (Figure 49.) This data collection diagram is shown in Figure 50.

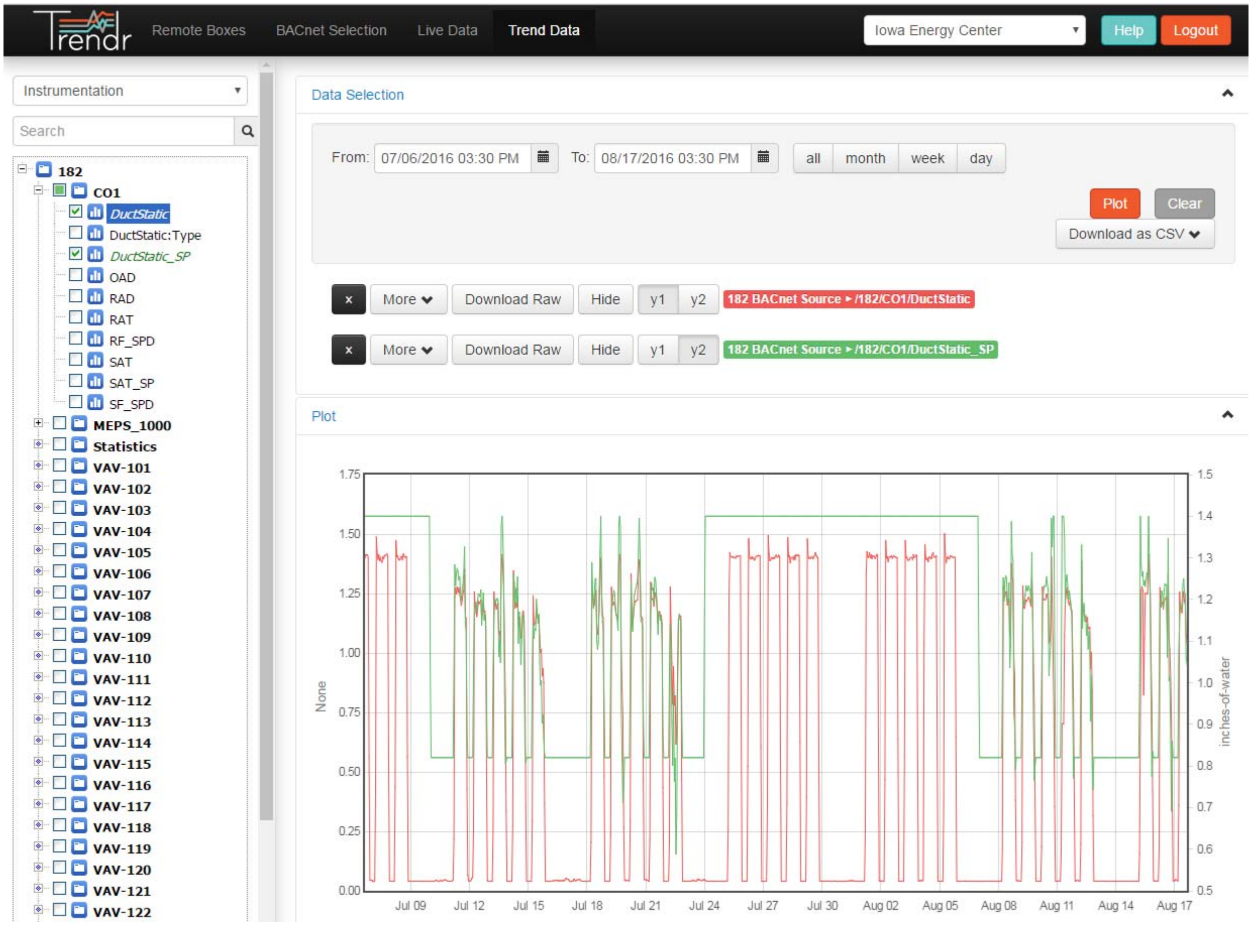

Figure 49. A Webpage Using Trendr Interface

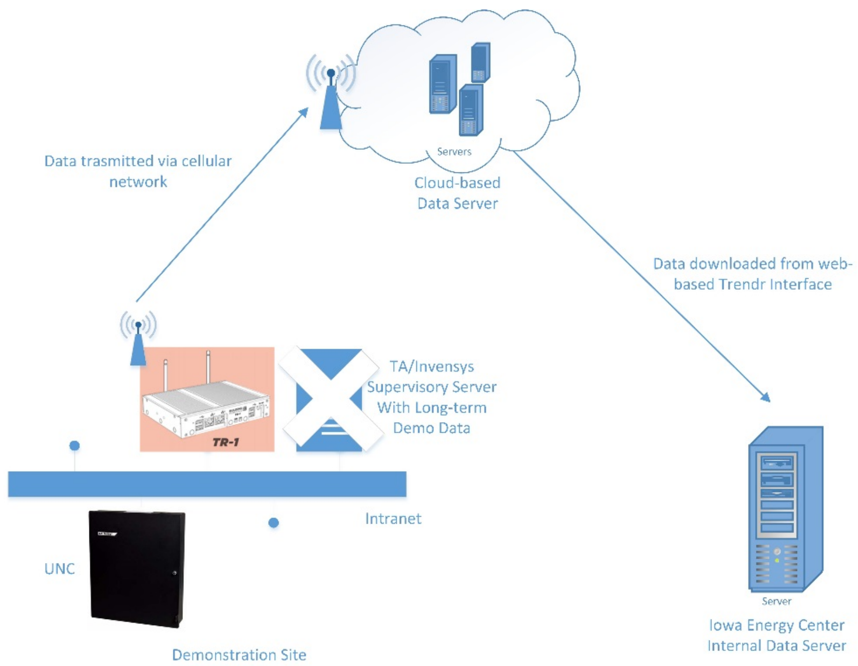

Figure 50. Data Collection Diagram #2 for Des Moines MEPS

5.6 SAMPLING RESULTS

Raw demonstration data were processed for data analysis following the data processing procedure described below:

Step 1: Combine demonstration raw data from different sources.

For each of the five demonstration sites, data collected from various sources (HVAC data, HOBO data) were first combined by running custom MATLAB program scripts and the results were then exported into Microsoft Excel spreadsheet templates. This process also synchronized dates/times from different data sources. These spreadsheet templates also have prebuilt charts showing how each AHU/RTU and VAV terminal unit perform in various control modes. These charts were used for routine monitoring and initial identification of problems with the demonstration.

Step 2: Identify "invalid demonstration dates."

During the one-year demonstration period, various issues and problems occurred which caused missing or invalid data on some testing days. These problems included:

- Building power outage
- Mechanical system failure
- Control system failure and building control network communication issues
- Data collection process failure due to hardware, software, or network communication issues

These invalid demonstration days were identified by the research team through review of demonstration data and discussion with IAARNG facility engineers and control contractors.

Actions were taken to fix these issues/problems as soon as possible so normal HVAC/ operation or data collection could resume. The data collected during these "invalid" days were excluded from the final data analysis.

<u>Step 3: Correct fan power data based on reference power meter field measurement</u>.

Fan power data were collected two different ways: through fan VFDs and additional watt transducers and HOBO data loggers. It is worth mentioning that VFD power measurements are for fan motor power only, excluding power consumption of the internal electronics of the VFD itself. Fan power data were collected using additional watt transducers and HOBO data loggers at the VFD power input side which include power consumption of the VFD. Additionally, these fan VFDs could have been in place for many years, and the accuracy of their readings may have been off compared to new ones. Therefore, field measurements comparing VFD power at input side using a reference power meter, VFD display, and HOBO data loggers at different power frequencies were done on several fan VFDs. Tables (Appendix G) summarizing these comparisons were used to correct fan power data from two separate sources to reflect the fan power measured at the VFD input side using the reference power meter. An illustration of field measurements and fan power corrections is shown in Figure 51.

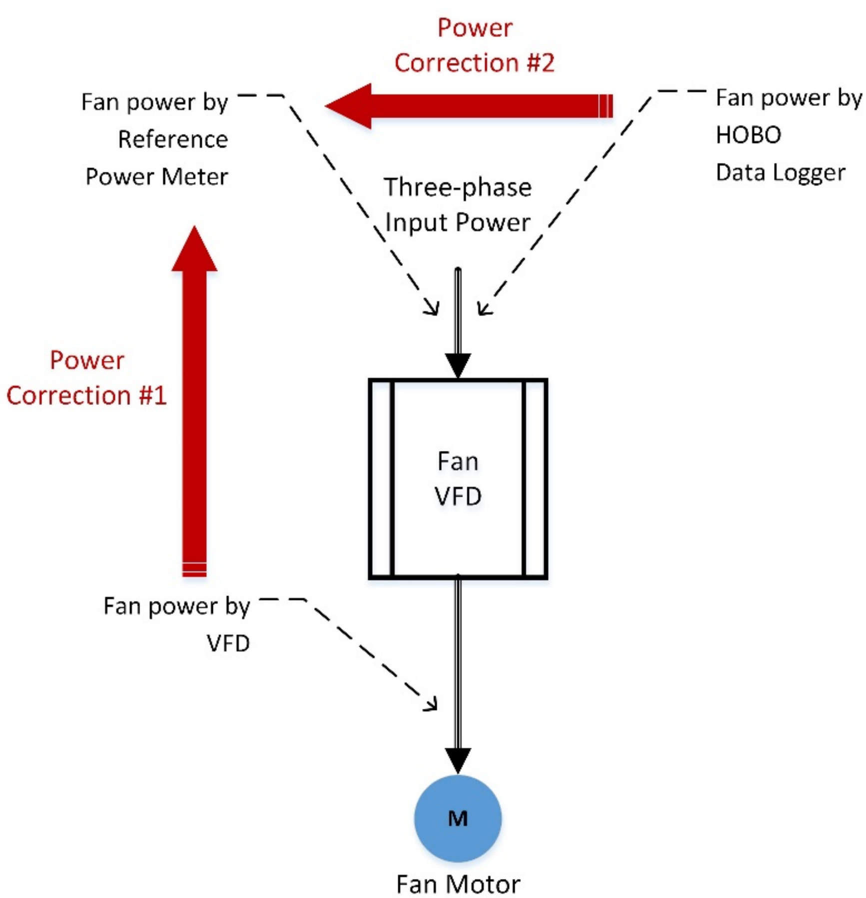

Figure 51. Fan Power Data Correction Illustration

Step 4: Calculate average daily fan energy use and derive average "nominal" weekly fan energy use.

Since the demonstration methodology was switching the AHU/RTU pressure control method once every two weeks, it was logical to compare energy savings using weekly results. However, some of the days during a week could have included unexpected problems (see Step 2) that caused missing data or "invalid" data. To fully utilize the rest of the "valid" data collected, daily fan and "nominal" weekly energy use were used here for energy saving comparisons. For each day, 1 or 2-minute "corrected" fan power data from Step 3 were used to calculate daily fan energy use. For each week, "nominal" weekly fan energy use was calculated by averaging "valid" weekday results times 5, plus averaging "valid" weekend day results times 2.

Daily fan energy use raw data, corrected data, and average "nominal" weekly data are shown in Appendix F.

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6.0 PERFORMANCE ASSESSMENT

6.1 QUANTITATIVE PERFORMANCE

6.1.1 Facility Energy Use

Analytical Methodology: AHU fan power data was continuously collected during the one-year demonstration period, and simple statistical methods were used to compare projected annual energy savings for AHU fans and the whole building.

Rationale: The main objective of this demonstration project was to document actual energy savings when using the TTR method. So it made sense to use directly recorded building energy and fan energy data for the alternating benchmark period vs. new TTR method period (rather than using building energy simulation models).

Fan energy savings based on nominal average weekly results:

Results for 11 AHU/RTUs that were evaluated to compare fan energy savings for TTR vs. Fixed Pressure are listed in the following table (Table 10). The baseline period represents the days that the Fixed Pressure method was applied.

Table 10. Summary of TTR Fan Energy Savings Percentage

Site	Unit	FSP kWh/weekly	TTR kWh/weekly	% Fan Energy Savings	% Total Fan Energy Savings
#1: JFHQ	AHU-1	555.23	511.69	7.84%	14.41%
	AHU-4	284.82	247.83	12.99%	
	AHU-9	108.03	50.94	52.85%	
	AHU-12	3164.47	2714.67	14.21%	
#2: Muscatine AFRC	RTU-1	19.01	15.97	16.00%	33.53%
	RTU-3	467.95	352.21	24.73%	
	RTU-4	422.52	282.77	33.08%	
#3: Waterloo RC	RTU-1	288.83	188.40	34.77%	34.77%
#4: Boone RC	AHU-1	602.10	415.45	31.00%	16.47%
	AHU-2	661.10	651.30	1.48%	
#5: Des Moines MEPS	AHU-1	454.22	373.23	17.83%	17.83%

In all cases, the TTR method saved fan energy compared to the Fixed Pressure method. The percentage savings for each AHU/RTU, however, vary significantly from 1.5% to 52.9%. The total fan energy savings for the five demonstration sites ranged from 14.4% to 34.8%. The empirical demonstration shows that the TTR method can still save a significant amount of fan energy for various DoD building types with different DDC systems. The demonstration results are reasonable because, in theory, the TTR would save somewhat less energy than the traditional TR method, and the 30% energy saving goal is based on past case studies comparing the traditional TR method to the Fixed Pressure method in non-DoD commercial buildings.

Buildings can be complex, especially those with additions/alterations and different mechanical system types, ages and control strategies. The differences in percentage fan energy savings at these IAARNG demonstration sites may be due to many factors including:

- System design issue: two independently controlled systems, a VAV system for (mostly) cooling and a radiant floor system for heating, causing frequent simultaneous heating and cooling and ineffectiveness of AHU pressure reset based on maximum zone damper positions.
- System design/commissioning issue: at the design AHU supply air static pressure, mechanical systems may generate significant noise and caused high static pressure sensor trips, so facility engineers often ran the AHUs at a much lower static pressures. This reduced the TTR method energy savings potential.
- System commissioning issue: VAV terminal units heating/cooling parameters were not set based on design or have unnecessarily high VAV minimum airflow setpoints.
- Building HVAC operations issue: boiler and chillers were not always controlled automatically by the building automation system. In some cases, facility engineers enable/disable them based on outside weather conditions.
- Building HVAC operations issue: AHU/RTU supply air temperature may have been inappropriately reset.
- Building control system components fail or degrade over time.
- Facility engineers' lack of time to monitor the system closely.

Detailed implementation issues and the cause of TTR ineffectiveness are discussed in Chapter 8.

Figures 52 to 55 illustrate several examples of TTR vs. Fixed methods' static pressure, fan power and VAV damper positions/commands.

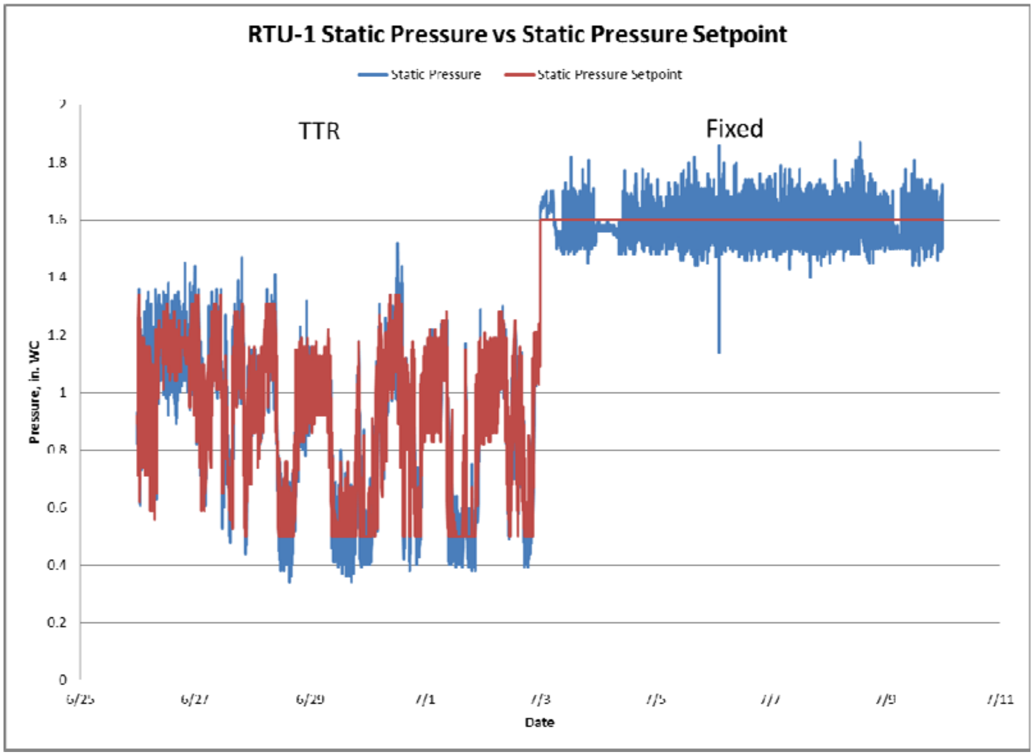

Figure 52. Static Pressures for TTR vs. Fixed for Waterloo RTU-1

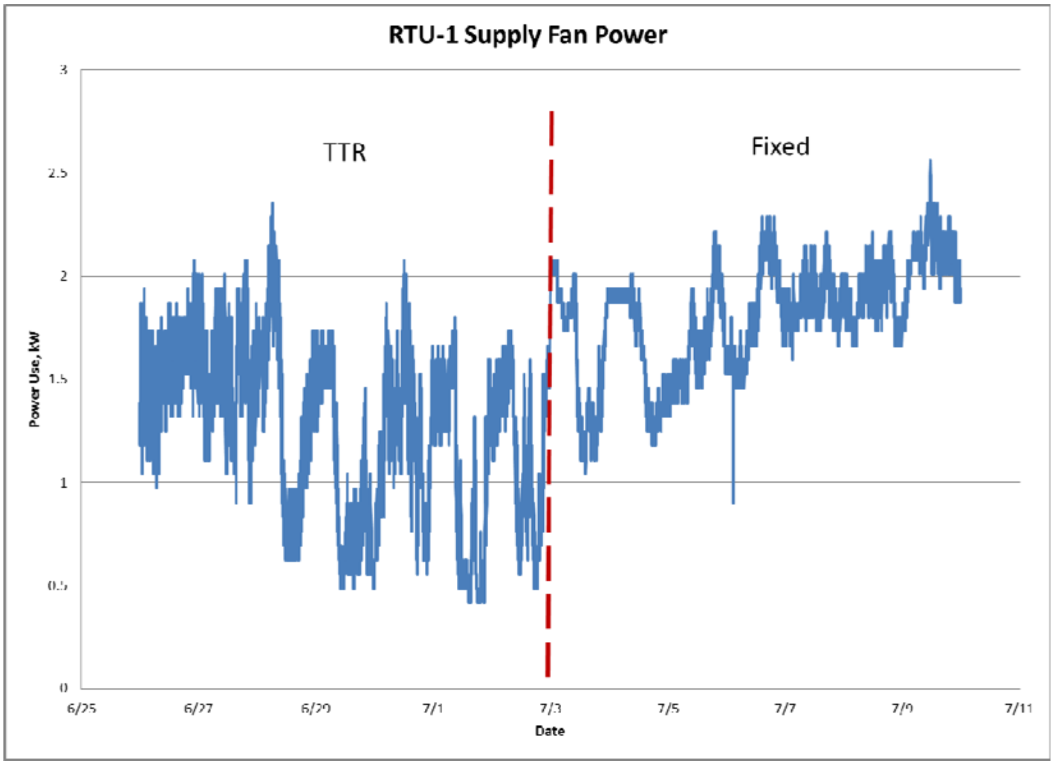

Figure 53. Fan Powers for TTR vs. Fixed for Waterloo RTU-1

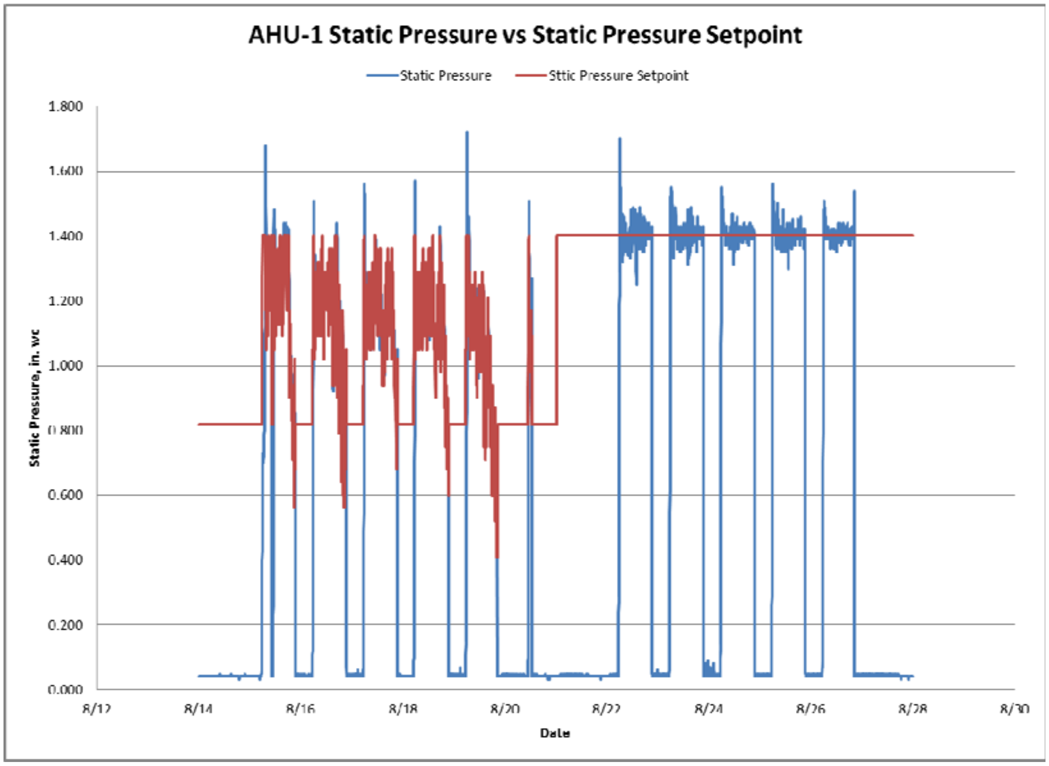

Figure 54. Static Pressures for TTR vs. Fixed for MEPS AHU-1

Figure 55. Damper Positions for TTR vs. Fixed for MEPS AHU-1

Projected annual fan energy savings for these sites:

Because daily weather conditions may or may not significantly affect AHU/RTU total fan energy use, correlations between total fan energy use and daily average outside air temperatures were explored using scatter plots. Polynomial curve fitting or linear regression was used to express the relationships. Figures 56 to 60 show scatter plots and correlations for each of the five demonstration sites.

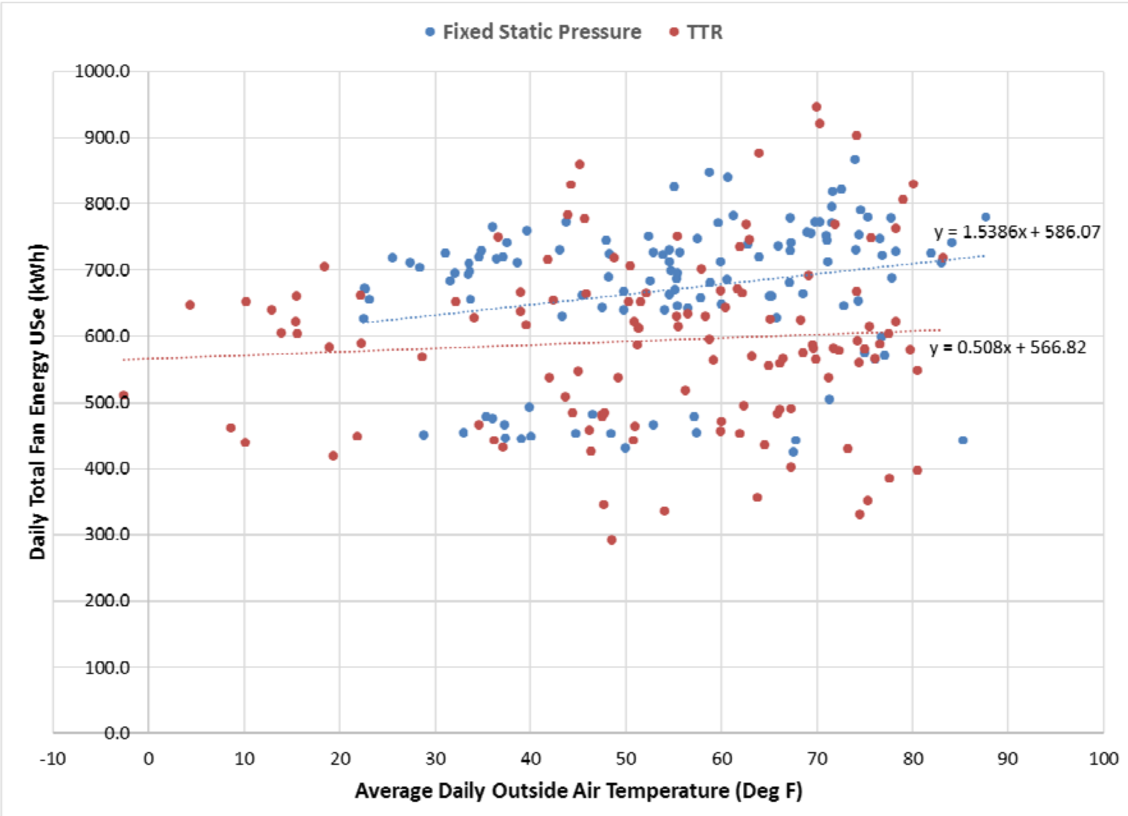

Figure 56. Daily Average OAT vs. Daily Total Fan Energy Use for Site #1

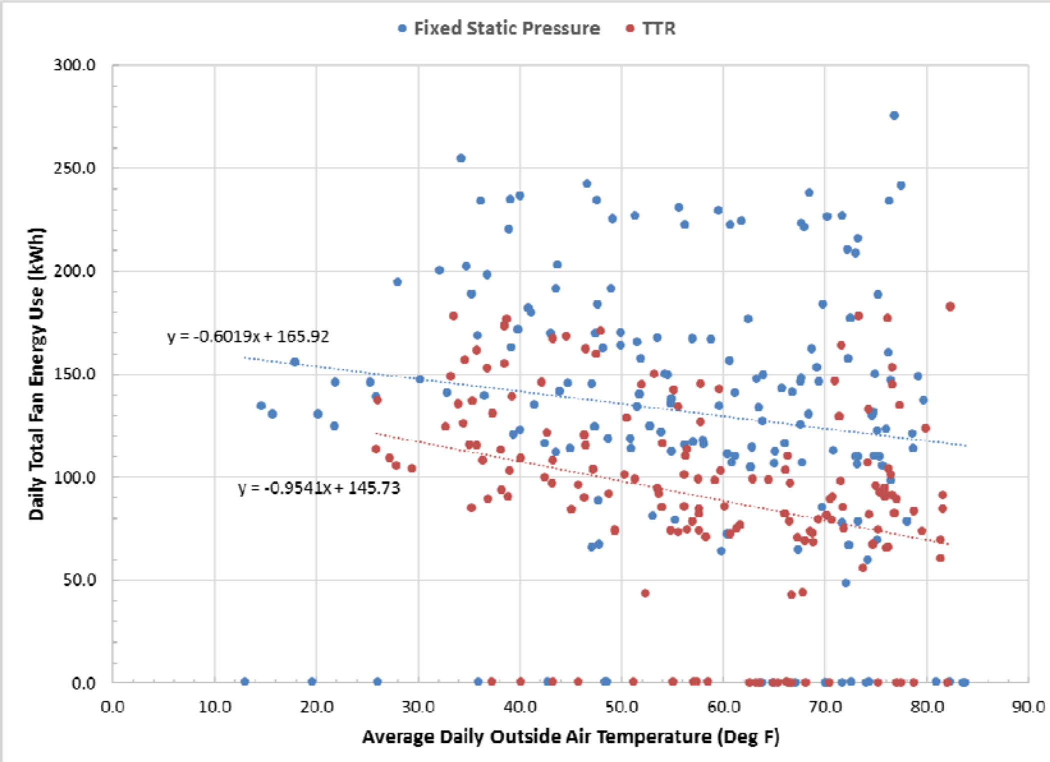

Figure 57. Daily Average OAT vs. Daily Total Fan Energy Use for Site #2

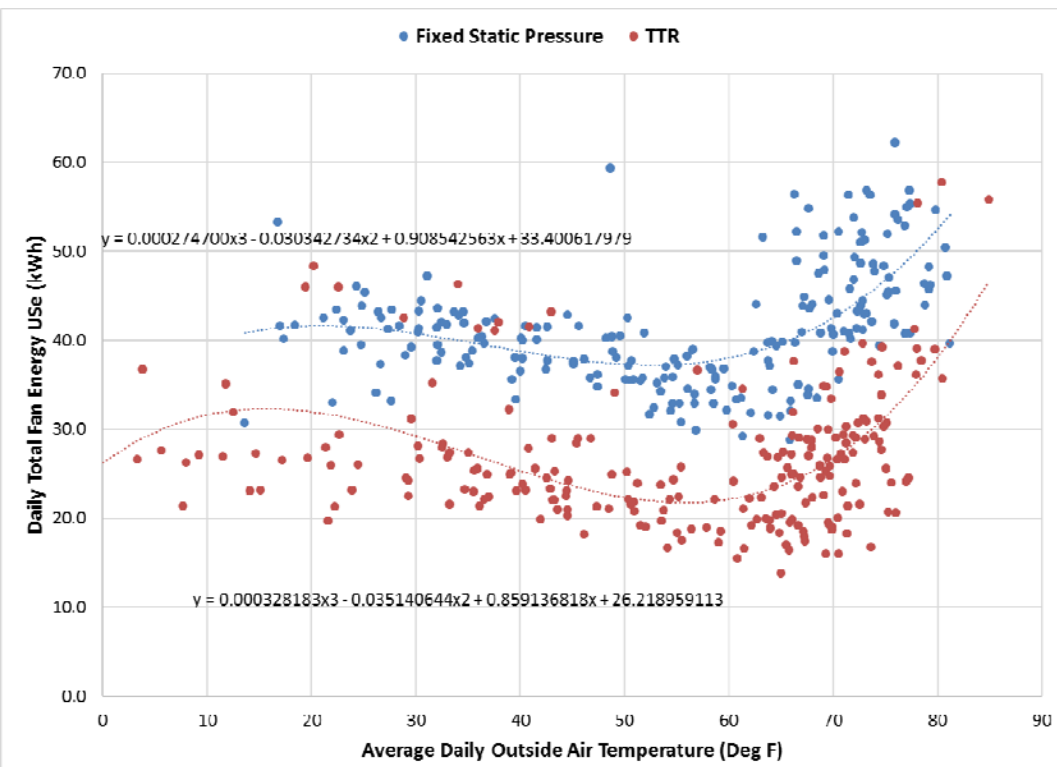

Figure 58. Daily Average OAT vs. Daily Total Fan Energy Use for Site #3

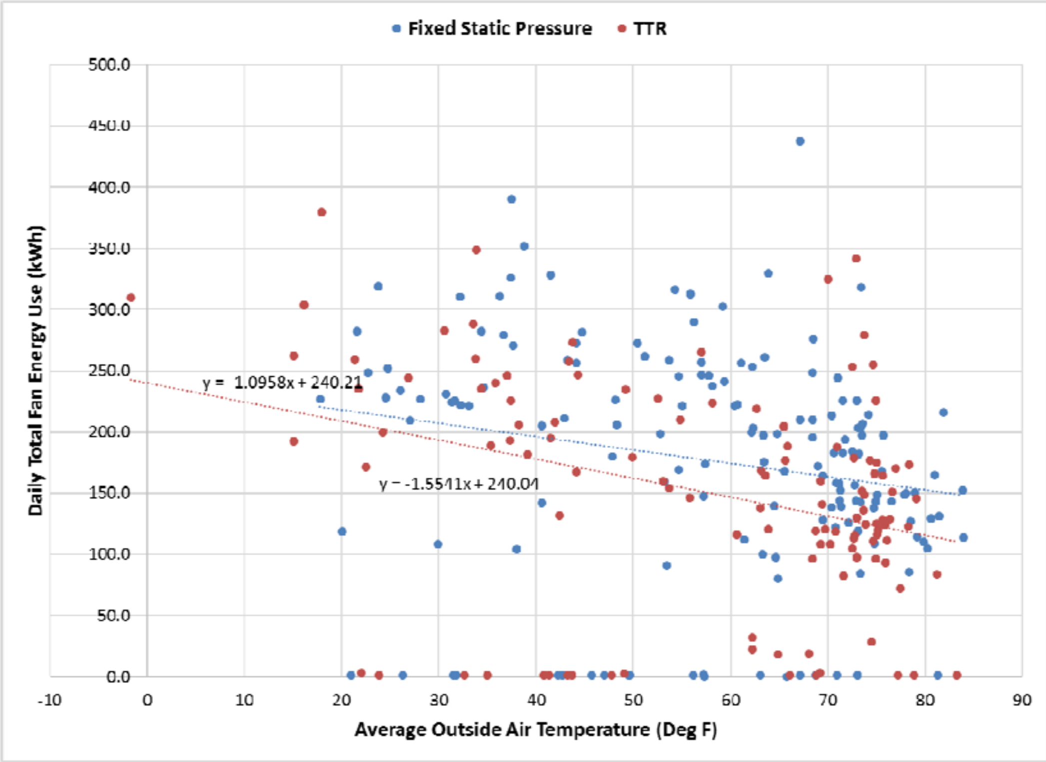

Figure 59. **Daily Average OAT vs. Daily Total Fan Energy Use for Site #4**

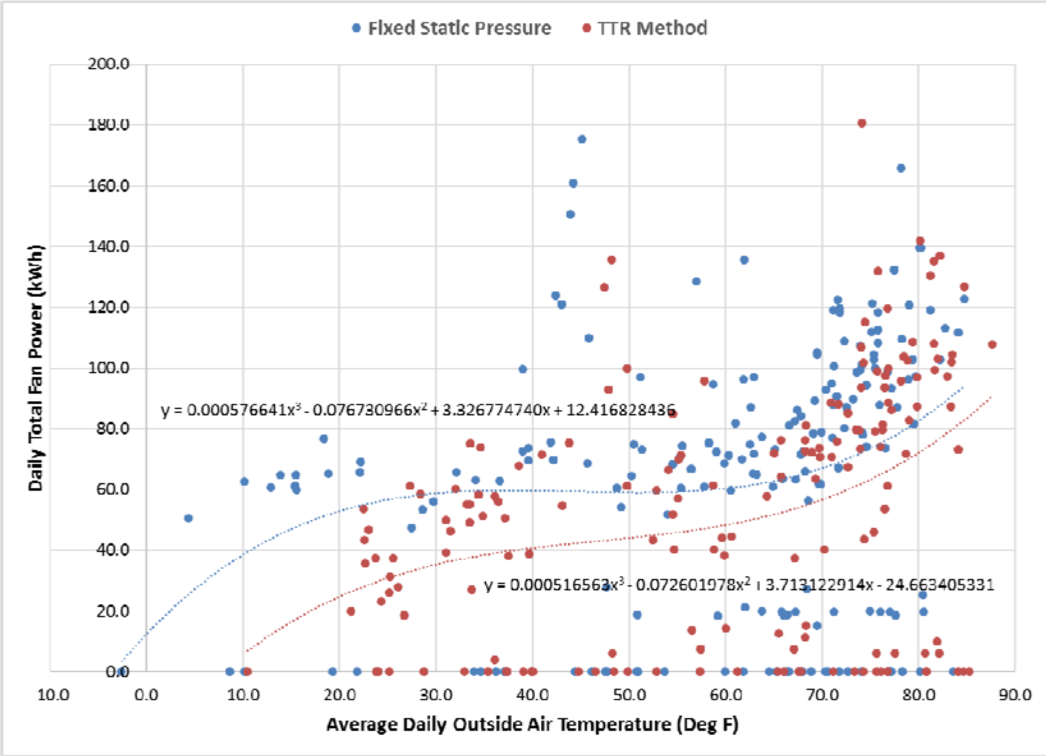

Figure 60. **Daily Average OAT vs. Daily Total Fan Energy Use for Site #5**

Applying these equations to the days' AHU/RTUs run at different static pressure control modes or days with missing data, annual total fan energy can be projected for both Fixed Pressure method and TTR method for a specified demonstration period:

Projected annual total fan energy (Fixed Pressure) = Measured total fan energy (for Fixed Pressure mode days) + Projected total fan energy (for TTR mode days)

Projected annual total fan energy (TTR) = Measured total fan energy (for TTR mode days) + Projected total fan energy (for Fixed Pressure mode days)

Table 11 summarizes the result of projected annual fan energy savings for a one-year demonstration period.

Table 11. Summary of Project Annual Total Fan Energy Savings

Site	Unit	FSP Projected Total Fan Annual Energy Use (kWh)	TTR Projected Total Fan Annual Energy Use (kWh)	Projected Annual Total Fan Energy Savings (kWh)
#1: JFHQ	AHU-1, 4, 9 &12	244,459.71	216,932.06	27,527.65
#2: Muscatine AFRC	RTU-1, 3 & 4	48,887.73	34,363.39	14,524.34
#3: Waterloo RC	RTU-1	16,354.70	10,764.50	5,590.20
#4: Boone RC	AHU-1 & 2	67,293.81	58,338.09	8,955.72
#5: Des Moines MEPS	AHU-1	23,003.84	17,269.59	5,734.25

Analysis:

Two of the five demonstration sites met the project goal of 30% fan energy use reduction, while the other three fell short. The 30% goal was based on properly designed, commissioned, and operated VAV mechanical and control system, and no degradation in system performance over time. In reality, all are not guaranteed. Key lessons learned from the demonstration project are summarized below:

- Improperly designed VAV systems may prevent a static pressure reset strategy (TR or TTR) from being effective in saving energy. For example, for site #1, some of the original design static pressure setpoints were 2.25 and 3.0 inch WC respectively; however, when running at these pressure setpoints, the significant noise could be heard by occupants, and sometimes debris fell from ceiling diffusers. Facility engineers, therefore, had to lower the static pressure setting to a fixed setting of 1.50 inch WC. While this reduced fan energy use and set a higher bar for this demonstration, it ran the risk of the system not satisfying designed heating/cooling load in certain conditions. Another design issue for Site #1 is that the VAV system and radiant heating system control zones overlapped and the zone temperature controls for the two systems were not coordinated. Some zones always operated at 100% cooling demand, with the VAV damper fully open, and the TTR was effectively operated as a fixed static pressure control and did not reduce fan energy.

- System operations are not always based on design intent. AHU static pressure reset strategy such as TTR method's effectiveness depends highly on proper supply air temperature and air flow being delivered to zones at all times. The availability of chilled and hot water and proper temperatures to AHU coils and VAV reheat coils significantly impact the performance of TTR control. Any related mechanical or control failure, improper manual scheduling of chiller and boiler's enable/disable period, or AHU supply air temperature reset based on outside air temperature rather than system cooling demand, could negatively impact the overall system performance.
- Building control system fails or degrade over time. Energy savings were typically largest immediately after first programming of TTR and commissioning the system. Performances degraded over time due to various mechanical and control hardware issues: thermostats not working and VAV differential pressure sensor drift. The controls contractors needed to be contacted to investigate these problems and fix them. Control system hardware and software stability and quality are very important in the long-term performance of the static pressure reset strategy, particularly in these demonstration sites. Facility engineers were typically very busy with daily operation and maintenance of multiple buildings (sometimes more than one hundred), and it was not always possible for them to monitor individual system performance and identify potential causes.

6.1.2 Indirect Greenhouse Gas Emissions:

Analytical Methodology: Use EPA Greenhouse Gas Equivalencies Calculator (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator or https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references).

Rationale: EPA's Greenhouse Gas Equivalencies Calculator is the method used by EPA to estimate equivalent greenhouse gas emission reductions related to reductions of kilowatt-hour of electricity from energy efficiency or renewable energy programs.

Baseline emissions generated:

Baseline emissions generated = Projected annual building electricity used when AHU/RTUs operated in Fixed Pressure Control mode × Emissions factor (7.03×10^{-4} metric tons CO_2 / kWh)

The emissions factor (7.03 × 10-4 metric tons CO2 / kWh) is based on eGRID, U.S. annual non-baseload CO2 output emission rate; year 2012 data.

Projected annual building electricity used in the baseline period is calculated based on daily total building electricity use in Fixed Pressure Control mode, normalized for weather.

Table 12. Summary of Baseline Emissions Generated by Each Site

Site	Projected Annual Fan Energy Use (Baseline, kWh)	Average Fan Energy Use Percentage	Projected Annual Total Building Energy Use (Baseline, kWh)	Projected Annual GHG Emissions (metric ton of CO2)
#1: JFHQ	244,460	5.0%	4,860,034	**3,416.6**
#2: Muscatine AFRC	48,888	15.8%	308,530	**216.9**
#3: Waterloo RC	16,355	2.5%	645,224	**453.6**
#4: Boone RC	67,294	12.9%	521,091	**366.3**
#5: Des Moines MEPS	23,004	5.9%	392,960	**276.3**

Emissions reduction percentages:

The projected annual electricity savings for each site is described in Section 6.1.1. The following simple formula is used to calculate emission reduction from reduced use of electricity by AHU/TRU fans:

Emissions reductions = Annual reduction of electricity by AHU/RTU fans (kWh) × Emissions factor (7.03 × 10^{-4} metric tons CO2 / kWh)

For each demonstration site, Indirect Greenhouse Gas Emission reduction percentages are listed in Table 13.

Table 13. Summary of Emissions Reduced

Site	Projected Annual Fan Energy Savings (kWh)	Projected Annual GHG Emissions Reduced (metric ton of CO2)	Emission Reduction Percentage
#1: JFHQ	27527.65	**19.35**	**0.6%**
#2: Muscatine AFRC	14524.34	**10.21**	**4.7%**
#3: Waterloo RC	5590.20	**3.93**	**0.9%**
#4: Boone RC	8955.72	**6.30**	**1.7%**
#5: Des Moines MEPS	5734.25	**4.03**	**1.5%**

Analysis:

The project team established a goal of reducing indirect greenhouse emission percentages by 6% over the established GHG baseline - based on the assumption of 30% AHU/RTU fan energy reduction and fan energy use of 20% of total building energy. The explanations for why fan energy reductions at some sites did not meet the 30% target is discussed in Section 6.1.1. While the AHU/RTU fan energy reduction goal of 30% was partially met, the project fell short of meeting the GHG reduction goal of 6%. The main reason is that the actual AHU/RTU fan energy were much smaller than 20% of total building energy for these demo sites. Some of these sites have other types of HVAC systems, such as constant-air-volume system or radiant heating system that do not vary fan speeds.

6.1.3 System Economics:

Analytical Methodology: Simple spreadsheet analysis was used in simple payback year calculation. The latest version of the NIST Building Life Cycle Cost Analysis (BLCCA) program (https://energy.gov/eere/femp/building-life-cycle-cost-programs) was used for Savings-to-Investment Ratios calculations.

Rationale: There are many ways to perform economic analysis for an investment activity. Simple payback in term of “years” is a common, simple way to estimate how many years an investment will take to “break even.” However, it does not consider the time value of money, and therefore many important factors such as inflation and discount rate are ignored in the calculation. NIST’s BLCCA is a standard program used by DOE, DoD and other federal agencies to assess energy efficiency investment’s overall near term and long term cost/benefit, so it makes sense to have used it in this demonstration project.

Utility rates:

Local utilities may have different rate structures for the demonstration sites, and often energy use charge is only a (sometimes small) portion of the utility bill. Other charges could include basic service charge, transmission service charge, on-peak and off-peak demand charges, and franchise fee. Monthly building utility bills were collected during the demonstration period, average electricity rates were calculated based on available most recent 12 months’ data.

Table 14. Annual Average Electricity Rates

Site	Monthly Data Period	Total Electricity Use (kWh)	Total Electricity Cost ($)	Average Electricity Rate ($/kWh)
#1: JFHQ	8/1/2015 - 7/31/2016	4,927,629	$268,969	**0.055**
#2: Muscatine AFRC	8/1/2015 - 7/31/2016	291,752	$28,300	**0.097**
#3: Waterloo RC	9/3/2015 - 9/6/2016	623,550	$37,860	**0.061**
#4: Boone RC	8/31/2015 - 9/1/2016	478,657	$48,360	**0.101**
#5: Des Moines MEPS	7/1/2015 - 6/30/2016	338,299	$18,216	**0.054**

Projected annual fan energy cost savings for these sites:

Table 15. Summary of Projected TTR Annual Fan Energy Cost Savings

Site	Annual Total Fan Energy Savings (kWh)	Average Electricity Rate ($/kWh)	Annual Total Fan Energy Cost Savings ($)
#1: JFHQ	27,527.7	$0.055	**$1,514.02**
#2: Muscatine AFRC	14,524.3	$0.097	**$1,408.86**
#3: Waterloo RC	5,590.2	$0.061	**$341.00**
#4: Boone RC	8,955.7	$0.101	**$904.53**
#5: Des Moines MEPS	5,734.3	$0.054	**$309.65**

Energy cost savings vary significantly by site, due to differences in building size, type, function, the number of occupants, and effectiveness of the TTR methods.

Costs for implementing TTR and system troubleshooting/maintenance:

Invoices were collected from four control contractors who were involved in this demonstration project's TTR implementation, troubleshooting, training, maintenance/repair, and demonstration setup. Costs were analyzed to determine the portion of demonstration, or actual retrofit implementation, training, and troubleshooting/maintenance. Table 16 summarizes the results of costs analysis for the five sites:

Table 16. Summary of TTR Implementation Costs

Site	Hardware Capital Costs	Installation Costs	Maintenance	Operator Training	Total Cost
#1: JFHQ	$0	$5,850	$1,725	$0	$7,575
#2: Muscatine AFRC	$0	$1,043	$323	$1,042	$2,407
#3: Waterloo RC	$0	$598	$0	$1,072	$1,671
#4: Boone RC	$799	$3,904	$3,782	$2,176	$10,661
#5: Des Moines MEPS	$0	$1,875	$1,875	$880	$4,630

Simple Payback:

Simple paybacks are calculated using projected annual energy cost savings divided by the total costs of implementing TTR, training, and maintenance during the first year.

Table 17. Summary of TTR Simple Payback

Site	TTR Total Cost ($)	Annual Fan Energy Cost Savings ($)	Simple Payback (years)
#1: JFHQ	$7,575	$1,514	**5.00**
#2: Muscatine AFRC	$2,407	$1,409	**1.71**
#3: Waterloo RC	$1,671	$341	**4.90**
#4: Boone RC	$10,661	$905	**11.79**
#5: Des Moines MEPS	$4,630	$310	**14.95**

Economic analysis results show that the simple payback periods are from **1.7** years to almost **15** years for the five sites and all fall short of the project goal. The goal of one-year payback was based on the ISU campus building pilot project, and only considered the cost for onsite custom programming of TTR (at about 15 hours for each AHU with $100/hour labor rate and the benefit of ~$4,000 annual cost savings.) For this demonstration, there were multiple reasons that all five IAANRG sites fell short of meeting the project simple payback period goal:

- This demonstration is based on a building retrofit application. The overall cost of implementation includes not only the cost for control programming customization but also costs for retro-commissioning of the control systems to resolve “rogue” zone problems, training, troubleshooting and maintenance during the one-year demonstration period. For new construction, static pressure reset is prescriptively required, and the incremental first cost is minimal.
- Local control contractor labor rates at some sites were higher than initially estimated. Some controls contractor charged up to $150/hour for field work, training, or project management.
- Significant costs incurred at some sites in troubleshooting and fixing rogue zones during the demonstration. These costs were not considered in the initial simple payback estimation. These costs can be reduced or avoided if facility engineers have the skills to troubleshoot and fix problems themselves.
- Training to IAARNG facility engineers was intended for them to learn the basic concept of static pressure reset and learn skills to monitor system performance and notify control contractor whenever the TTR algorithm is no longer effective. The training may not be necessary if control contractor would do a routine check and maintenance on-site.
- The supply and return fans at some sites were very small in size and capacity. The fan energy savings were not significant enough given relatively fixed cost implementing the control software customization.
- At some of these DoD facilities, local electricity rates were very low.
- The HVAC systems in some of these buildings were not designed, commissioned, or operated properly.

Another way to calculate simple payback is to exclude the cost of addressing maintenance issues that ensure the TTR (or TR) resets work. However, the energy and cost savings would be different. A lesson learned in the project is that **the TTR method could have done much better with the ability to ignore some zones.** Ignores would allow TTR to reset more, reduce the vulnerability to a few problem zones and would have reduced the amount of effort spent to chase down every last rogue zone. The adverse impact of ignores may be minimal. Most people do not notice or complain when there is momentarily a little less flow or zone temperature temporarily out of comfort zone.

In many cases, it may not be economically justifiable just to retrofit the controls to do this one measure in isolation. There are plenty of other low hanging fruit energy measures to address altogether. The economics could be entirely different in those situations.

<u>Building Life Cycle Cost Analysis:</u>

The latest version BLCC 5.3-16 (for Windows) was downloaded and used in the building life cycle cost analysis in this report.

Assumptions and standard inputs:

- Use “MILCON Analysis, Energy Project” as the BLCCA 5 project template
- Discounting Convention: Mid-year Discounting
- Analysis Information: Constant Dollar Analysis

- Real Discount Rate: 3.0%
- Only electricity cost is considered in the “Energy Costs” category
- For the “Base case,” investment, maintenance, and repair costs are assumed “$0.”
- For “Demo case,” investment, maintenance, and repair cost are the real incremental costs compared to the “Base case.”
- Key Dates: Base Date – April 2016; Beneficial Occupancy Date (from Base Date): 4 months

Table 18. Summary of TTR BLCCA Results

Site	TTR Total Cost ($)	Annual Fan Energy Cost Savings ($)	SIR (5 years)	SIR (10 years)	SIR (20 years)
#1: JFHQ	$7,575	$1,514	-	-	-
#2: Muscatine AFRC	$2,407	$1,409	**2.11**	**3.99**	**7.04**
#3: Waterloo RC	$1,671	$341	**1.03**	**1.94**	**3.41**
#4: Boone RC	$10,661	$905	-	-	-
#5: Des Moines MEPS	$4,630	$310	-	-	-

Building Life Cycle Cost Analysis results show that if annual routine maintenance costs are similar to those in the first year, only two of the five sites would have positive energy and cost savings after 5, 10, and 20 years, with the best SIRs at Site #2. Because of the nature of the demonstration project and the need to resolve issues quickly, contractors were often brought to each site for special trips to address issues related to TTR. Maintenance costs could be reduced if the issues are instead addressed as part of the routine preventive maintenance checks on-site (some DoD facilities have annual maintenance contracts with local control contractors.)

6.2 QUALITATIVE PERFORMANCE

6.2.1 User Satisfaction

Analytical Methodology: User surveys were conducted and survey forms were collected during the one-year demonstration period.

Rationale: Through planned interviews with energy managers and facility personnel, anecdotal observations of the performance of the proposed control method was documented and analyzed.

A summary of the survey results is provided in Table 19.

Table 19. Summary of Survey Results

ID	Question	Selection	Response/Comments
1	What is your position at Iowa Army National Guard?	1. Facility manager 2. Building Operator 3. Other	Two answered "Facility Manager" and two chose "Other" and clarified they are "Facility Engineer."
2	Are you responsible for the daily operation and maintenance of the building HVAC system?	1 – Yes 2 – No	Three chose "Yes" and one clarify he was in charge of maintenance but not daily operation.
3	Are you aware of the static pressure reset control strategy before this project?	1 – Yes 2 – No	One selected "Yes', and three selected "No."
4	How is the air handling unit static pressure controlled in your building before the demonstration?	1 – Constant 2 – Trim and Respond (TR) 3 – Other reset strategy	One selected "1-constant", two selected "Not sure," and the one selected "Other reset strategy."
5	Do you find the new Tiered Trim and Respond (TTR) method easy to understand?	1 – Yes 2 – No	One "Yes," Three "No."
6	In the past three months, did you observe a significant difference in air handling performance between the old and new (TTR) method? Describe the difference (if there is any).	1 – Not at all 2 – Somewhat 3 – Significant	Two selected "Not at all." One selected "Somewhat", and the other one selected "significant" and explained the reason was that at the beginning of the demonstration period, when static pressure setpoint is close to design value, maintenance problems with noise, vibration, high-pressure sensor trip occurred, and the maximum setpoint had to be lowered to reduce the number of complaints.
7	In the past three months, did you observe a significant difference in building comfort (temperature, air quality, noise level)? Describe the difference (if there is any).	1 – Not at all 2 – Somewhat 3 – Significant	Two selected "Not at all." Two selected "Somewhat," and explained most related complaints (at the beginning of the demonstration) are noise caused by high static pressure and temperature out of control when high static pressure sensor was tripped, and AHU was shut down.

<u>Analysis:</u>

The facility engineers have different backgrounds and experience in facility maintenance, and may or may not have expertise in building HVAC systems and controls. Sometimes when HVAC equipment or control issues occurred, they had to coordinate with local mechanical or control contractors to resolve the issues. At three of the five sites, users did not have any additional complaints or differences in comfort level between the existing pressure control method and the TTR method. At one site, however, at the beginning of the demonstration, significant noise, vibration, and tripping of a high static pressure sensor occurred when the static pressure was set by TTR to approach the design values. Improper HVAC system design or commissioning was the key reason, and it significantly affected the effectiveness of the TTR method. IAARNG facility engineers had already lowered static pressure setpoint to almost half of the design value during daily operations to avoid these problems before the official demonstration started.

6.2.2 Scalability across the Department of Defense:

Analytical Methodology: Simple mathematical calculation.

Rationale: Estimate the overall energy savings across all Department of Defense buildings using energy savings at the five demonstration buildings.

Projected total fan energy savings and demonstration site building gross areas were used to calculate average energy savings per square foot for the demonstration sites. The ratio was used to project energy savings across the Iowa Army National Guard and DoD facilities. The total building areas for IAARNG was based on the Iowa Public Building Benchmarking Program database (https://ia.b3benchmarking.com/) where all of Iowa Public Defense' buildings and energy/cost information were entered and their building energy use are benchmarked. DoD's gross building area number is based on the "Base Structure Report – Fiscal Year 2015 Baseline" [DoD, 2016].

Projected annual energy cost savings are estimated based on projected annual total fan energy savings and average of $0.10/kWh across DoD facilities.

Table 20. Projected Annual Energy Savings per Building Gross Area

Site	Unit	FSP Projected Annual Total Fan Energy Use (kWh)	TTR Projected Annual Total Fan Energy Use (kWh)	Projected Annual Total Fan Energy Savings (kWh)	Building Area (sq. ft.)	Projected Annual Energy Savings (kWh/sq. ft.)
#1: JFHQ	AHU-1, 4, 9 &12	244,459.71	216,932.06	27,527.65	237,126	0.1161
#2: Muscatine AFRC	RTU-1, 3 & 4	48,887.73	34,363.39	14,524.34	37,392	0.3884
#3: Waterloo RC	RTU-1	16,354.70	10,764.50	5,590.20	84,764	0.0660
#4: Boone RC	AHU-1 & 2	67,293.81	58,338.09	8,955.72	77,321	0.1158
#5: Des Moines MEPS	AHU-1	23,003.84	17,269.59	5,734.25	28,200	0.2033
Five Sites:				62,332.17	464,803	**0.1341**

Table 21. Summary of TTR Scalability across IAARNG and DoD

Site	Projected Annual Energy Savings (kWh/sq. ft.)	Building Area (sq. ft.)	Projected Annual Energy Savings (kWh)	Projected Annual Cost Savings ($)
Five Demo Sites	0.134	464,803	**62,332**	**$6,233**
Iowa Army National Guard	0.134	3,840,000	**514,961**	**$51,496**
U.S. DoD	0.134	2,200,000,000	**295,029,861**	**$29,502,986**

6.2.3 AHU Fan Reset Strategy Technical Performance Comparison:

Analytical Methodology: Sample graphical and statistical analysis of daily AHU static pressure and setpoint changes for existing TR method and the new TTR method.

Rationale: Currently there is no strict definition of "control stability" so qualitative performance comparisons using graphical and statistical analysis of daily AHU static pressure and setpoint changes were used. Daily charts on the amplitude, frequency, rate of change for AHU or RTU static pressure and its setpoint were compared. Only the AHU-2 and AHU-3 at Site #1 where the existing pressure reset method was compared with the new TTR method.

The new TTR method was compared against existing TR approaches at Joint Forces Headquarters AHU-2 and AHU-3 to compare the technical performance of the different reset strategies. This section provides a summary of graphical and statistical analyses of setpoint changes to represent control stability. A comparison of the energy use of the different strategies is also provided. Two traditional TR approaches were evaluated and are referenced here as TR1 and TR2.

6.2.3.1 Comparison of Stability

Figure 61 shows the pressure setpoint for the two approaches at AHU-2 over a typical winter period spanning several weeks. The data were filtered to only show the setpoint during operating hours. The TR1 setpoint reset effectively during this period, but the TTR setpoint was largely restricted to its upper limit value. Figure 62 shows the pressure setpoint for the two approaches at AHU-3 over the same period. Both strategies reset during this period, but the TR2 strategy clearly operated at lower values than TTR.

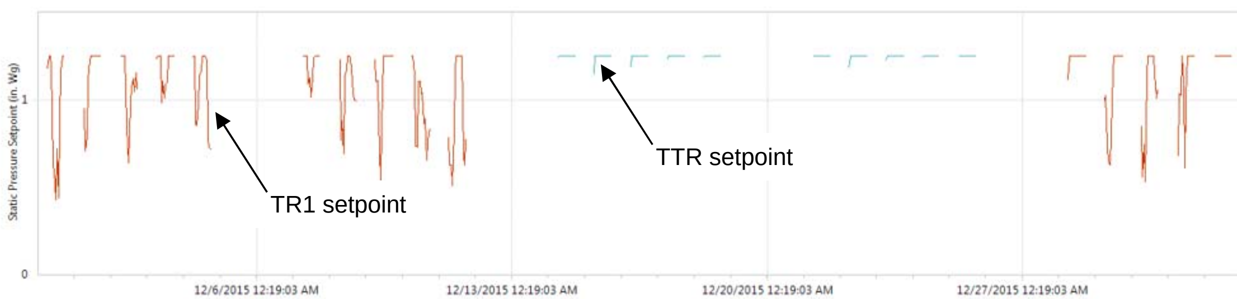

Figure 61. TTR vs. TR1 for JFHQ AHU-2

Figure 62. TTR vs. TR2 for JFHQ AHU-3

A statistical summary comparison of the setpoints, including amplitude, frequency, and rates of change, are provided in Table 22.

Table 22. Summary of TTR and TR Setpoint Statistics

	JFHQ AHU-2		JFHQ AHU-3	
	TTR	TR1	TTR	TR2
Average static pressure setpoint (in. Wg)	1.29	1.05	1.54	1.02
Deviance between measured static pressure and static pressure setpoint (in. Wg)	0.12	0.04	0.04	0.07
Average change in setpoint per hour (in. Wg / hour)	0.52	0.54	0.72	0.32
Percent of time that the static pressure setpoint is constant	90%	41%	31%	75%
Average setpoint cycles per occupied day (#/day)	1.2	5.9	9.9	1.4
Average cycle amplitude (in. Wg)	0.40	0.29	0.36	0.10

On average, the traditional TR strategies had lower setpoints than the TTR strategies at these two air handlers. The AHU-2 system exhibited operational issues that minimized the ability for the TTR strategy to reset effectively. Thus the statistical comparisons are not representative of the actual control stability between the two reset approaches. The TTR approach maintained a constant setpoint 90% of the time and exhibited 1.2 cycles per day on average, whereas the TR1 strategy was only constant for 41% of the time and exhibited 5.9 cycles per day. However, the apparent stability of the TTR approach was because the setpoint was typically maintained at its upper limit and was not resetting.

Air handler AHU-3 provided a more suitable case to analyze data, where the TTR strategy appears to adapt to feedback more often and responded faster than traditional static pressure requests. Ten cycles per work day on average is a stable and well-performing control sequence. The TR2 strategy operated at its lower limit for a large percentage of the time which skews the apparent stability.

6.2.3.2 Comparison of Energy Performance

The energy performance of the TTR and TR strategies was evaluated based on regression analyses adherent with the International Performance Measurement and Verification Protocol and using the Universal Translator software. This analysis used fan power data measured at one-minute intervals and developed a model to predict the fan power using the time of day and the outside air temperature.

Review of the data indicated that the fan power depended heavily on both outside air temperature (as a proxy for building load) as well as the time of day (there was often a significant increase in airflow at the onset of occupancy for morning cool down). The regression model created a “plane of best fit” by creating a prediction of fan power using time and temperature. Those models were then applied to outside air temperature data for a typical weather year for Des Moines to estimate the annual energy use for each approach. Figure 63 shows a plot of the predicted fan power for the TTR model (blue) and the TR1 model (red) for AHU-2 over several weeks in the spring.

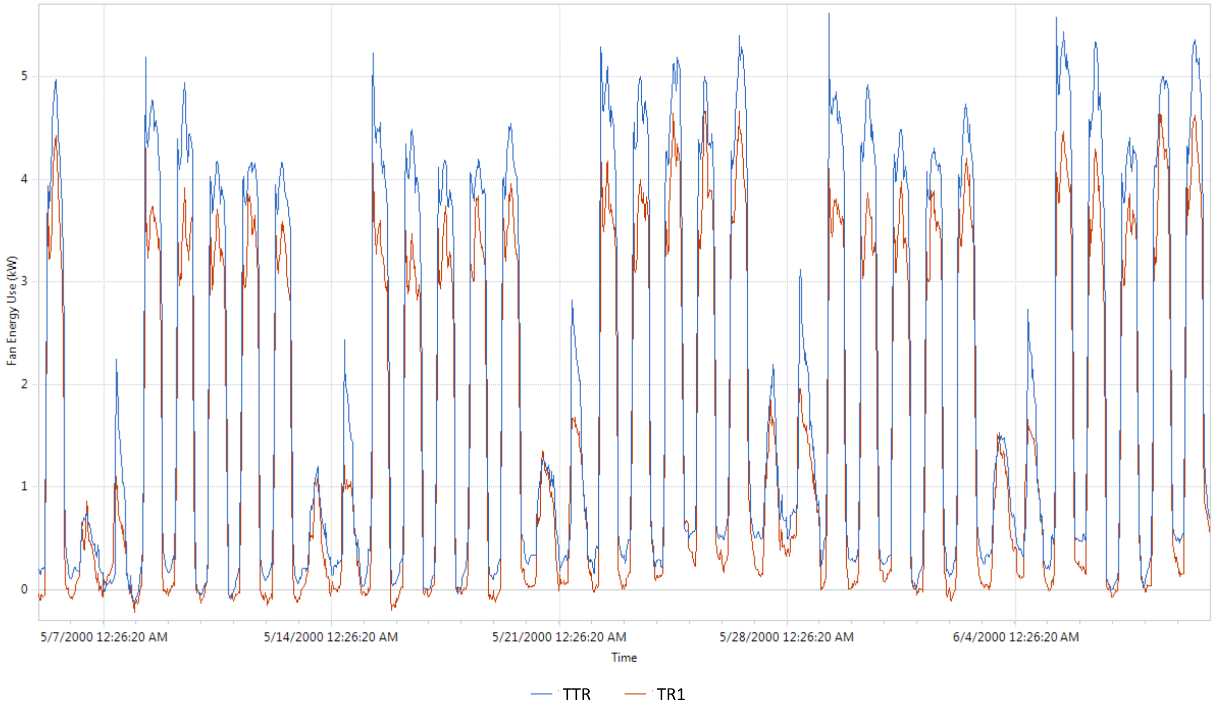

Figure 63. Predicted Fan Power for TTR and TR1 for JFHQ AHU-2

A summary of annualized energy performance based on the regression against outside air temperature and time is shown in Table 23. The TTR approach uses 15 percent more fan energy compared to the TR1 approach at AHU-2 and uses 30 percent more fan energy compared to the TR2 approach at AHU-3.

Table 23. Summary of TTR and TR Energy Performance

	JFHQ AHU-2		JFHQ AHU-3	
	TTR	TR1	TTR	TR2
Annual Energy Consumption (kWh)	16,550	13,990	18,714	12,930
Annual Energy Difference (kWh)	2,560		5,786	
Percent Energy Difference	15.5%		30.9%	

6.2.3.3 Discussion

The TTR reset approach operated at higher average setpoints and used more fan energy compared to the TR approaches at AHU-2 and AHU-3. The significant difference in operational and energy performance between the TTR and TR reset methods can be largely attributed to the ability of the TR methods to ignore the demand from a user-defined number of zones before increasing the pressure setpoint. In these cases, the TR1 method at AHU-2 was configured to ignore first 10 percent and the TR2 method at AHU-3 was set to ignore the first 20 percent of zones.

In contrast, the TTR method responded to satisfy the most demanding zone. At AHU-2, there was typically one "rogue" zone that could never meet its airflow setpoint, which forced the TTR method to operate at or near its maximum limit for much of the time. The ability to ignore some zones allows the TR strategies to reset more often to reduce fan energy but at the cost of providing less airflow to those zones and potentially not maintaining thermal comfort.

Air handler AHU-2 frequently had a small number of "rogue" zones that continuously operated at 100% damper position. This may be in part due to warm supply air temperatures, as the temperature setpoint resets up to 70 °F, or other factors unique to those zones.

The trends for the TR1 setpoint (blue) and requests (red) are shown in Figure 64 for two weeks in early November 2015. Requests are defined as zones where the damper was more than 95 percent open. There were typically 2 to 4 requests overall, and the setpoint was often near the maximum during the first week, but reset downward more frequently during the second week. There was some modulation as the setpoint reset and the number of requests cycled between values of 2 to 4.

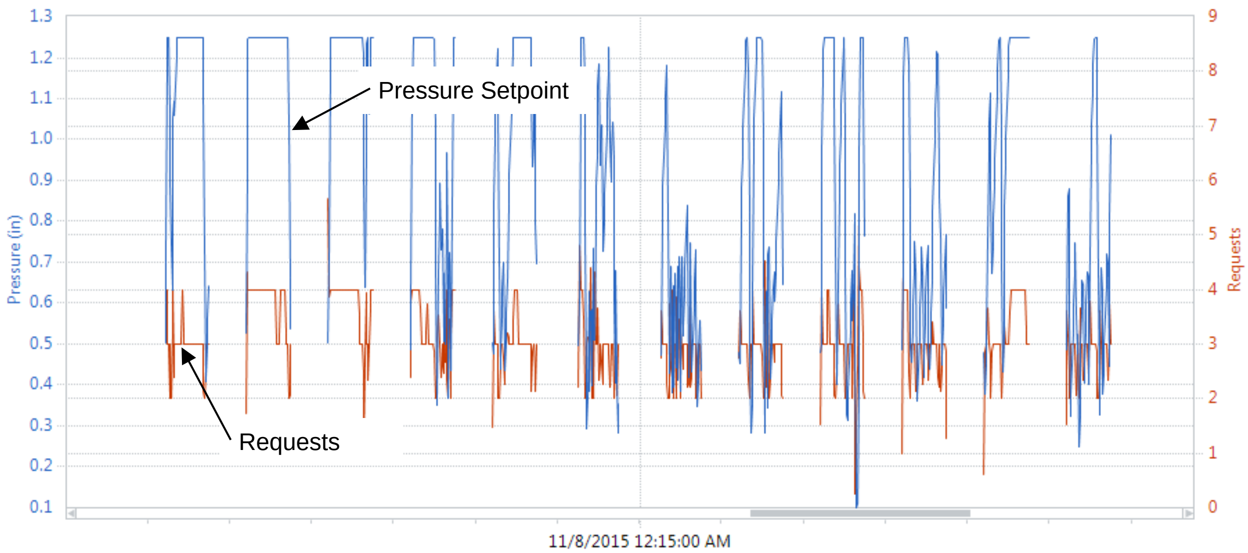

Figure 64. TR1 for JFHQ AHU-2

Figure 65 shows the TTR reset approach and the most-open damper position during the last two weeks in November 2015. During this period, the setpoint was often at its maximum limit, and the most-open damper was also at 100% as discussed above.

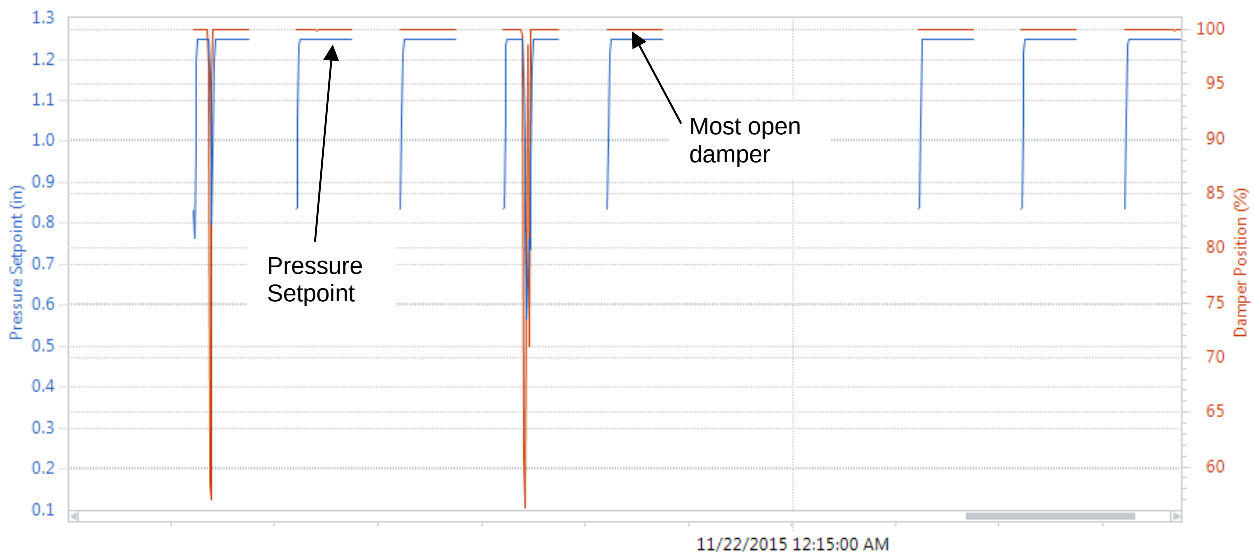

Figure 65. TTR for JFHQ AHU-2

The pressure setpoint and most-open damper position trends are shown in Figure 66 for one week where the TTR was active at JFHQ AHU-3. The setpoint modulated around 1.2 inch WC on average and the most open-damper position cycled between about 75 and 100 percent open.

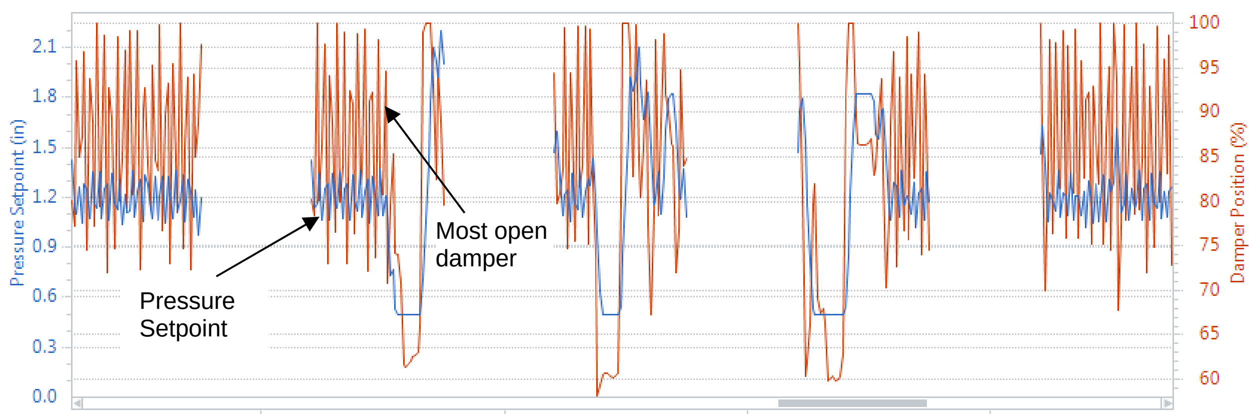

Figure 66. TTR and Most-Open Damper Position for JFHQ AHU-3

The same trends are shown in Figure 67 during a period where the TR2 was active. The most open damper position was nearly always at 100 percent, but the setpoint reset effectively. In this case, the pressure setpoint was allowed to reset even though there were some zones not satisfied.

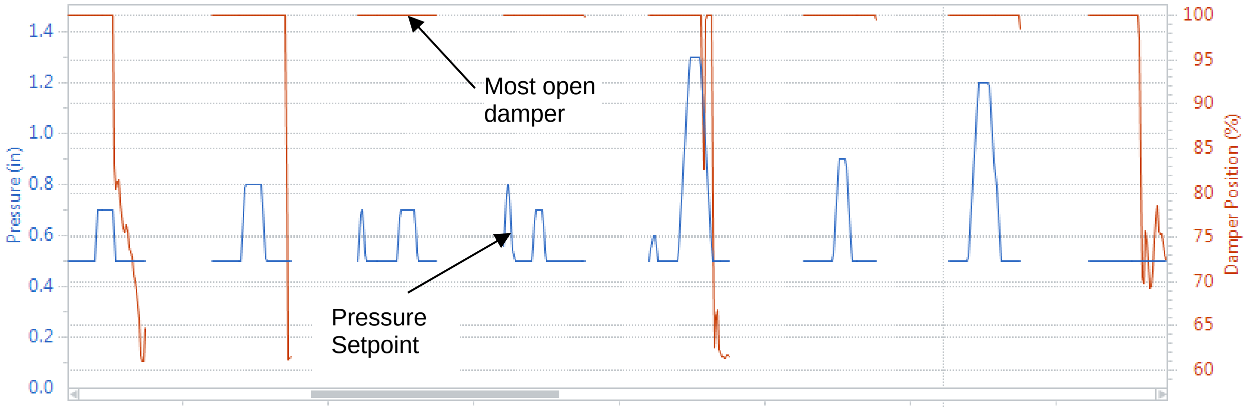

Figure 67. TR2 and Most-Open Damper Position for JFHQ AHU-3

7.0 COST ASSESSMENT

7.1 COST MODEL

A simple cost model for implementing the TTR technology is presented in Table 24. Cost estimates are based on actual costs for the five demonstration sites.

Table 24. Cost Model for TTR Implementation

Cost Element	Site #1 (6 AHUs & 208 VAVs)	Site #2 (3AHUs & 36 VAVs)	Site #3 (1 AHU & 14 VAVs)	Site #4 (2 AHUs & 66 VAVs)	Site #5 (1 AHU & 34 VAVs)	Cost Range
Hardware Capital Costs	$0	$0	$0	$799	$0	**$0~$799**
Installation Costs	$5,850	$1,043	$598	$3,904	$1,875	**$598 ~ $5,850**
Maintenance	$1,725	$323	$0	$3,782	$1,875	**$0 ~ $3,782**
Operator Training	$0	$1,042	$1,072	$2,176	$880	**$0 ~ $2,176**
Site Totals	*$7,575*	*$2,407*	*$1,671*	*$10,661*	*$4,630*	***$1,671 ~ $10,661***

The cost elements are explained below:

Hardware capital: There should not be any hardware capital costs for implementing the TTR method on existing DDC systems. There could be some hardware capital costs associated with correcting “rogue” zones to improve the TTR method control performance, such as replacing failed temperature sensor or VAV differential pressure sensor.

Installation: This is the labor cost for the controls contractor to implement the TTR method on-site according to TTR method control sequence specification. Typically this cost varies depending on the control technician/engineer’s charged rate, skills, and the number of AHU and VAVs involved.

Maintenance: Cost related to troubleshooting and fixing of various mechanical and control issues that prevented effective TTR algorithm. Typically this is done by a controls contractor.

Operator training: Training needed for building operators and local facility engineers to understand the TTR method theory, operation, maintenance, system monitoring, and data collections. Typically this is done by a controls contractor.

The installation cost increased approximately proportionally with the number of AHUs. The sizes of the supply and return fans do not matter much. The maintenance costs were largely dependent on how well the HVAC system was commissioned, maintained, operated, and the service rate for control contractors.

The biweekly control strategy changes at all five sites were done automatically through simple programming by local controls contractors. It took a few hours of contractors' time to set it up at each location. Since the biweekly control mode switchover is only needed for this demonstration project and not part of a normal retrofit project, the labor costs for programming the biweekly switchover is not counted in the TTR implementation cost. For a retrofit application, changing control mode from Fixed Pressure Control to TTR/TR would be a single event, and the cost would be minimal.

The five sites involved different types of mechanical and control systems and four different control vendors. Factors most affecting the costs associated with the implementation and maintenance of the effective TTR operation include:

- Control contractor's labor rate
- Number of VAV terminal units involved
- Quality and stability of the building control system hardware and software
- Properly designed and operated mechanical system

Since TTR implementation cost is mostly labor cost, control contractors' labor rates are a significant factor in the overall cost. The control contractors charged between $100 to $150 per hour during this demonstration project for implementing TTR program and troubleshooting control/HVAC issues on-site. Some contractors also charge program manager's time for managing projects.

The more AHU or RTU units that are involved in implementing TTR, the more time is needed in custom programming and troubleshooting of TTR. The more VAV terminal units that are controlled by one AHU or RTU, the higher chance that TTR will not be effective in saving energy – if the TTR method does not have the capability to ignore a certain number of rogue zones.

Buildings with high-quality control hardware and software and those are sufficiently maintained will have fewer operational issues that may adversely impact the effectiveness of the TTR algorithm. Problems with control sensors, actuators, building HVAC network and communication could all have a negative impact on the overall effectiveness of TTR. The need to have control contractors troubleshooting to resolve these issues on-site added increased maintenance cost.

If a mechanical system was not properly designed or there were many alterations to the original building space and mechanical system, TTR may not be effective. Each terminal units' parameters should be carefully reviewed and units commissioned. Mechanical system operations should follow design intent. Otherwise, costs related to troubleshooting and fixing these issues could be significant over time.

Scalability is not an issue for TTR implementation. It is desirable and more cost effective to implement TTR on systems with large AHUs or RTUs. The cost for TTR software customization is <u>not</u> proportionally higher for larger AHU or RTUs, but the benefit of fan energy savings could be significantly more.

7.2 COST DRIVERS

When selecting the technology for future implementation, factors discussed in the previous section should be fully considered. The most significant cost comes from installation and tuning of the TTR method. Maintenance cost of fixing various issues comes second. Improper monitoring and maintenance of HVAC and building control systems could reduce the effectiveness of TTR method long-term. Unfortunately, DoD facility maintenance staff often do not have enough time to perform detailed monitoring of HVAC system operations and performances. When problems occur, the control contractors often need to be called for an on-site investigation. A facility in need of maintenance or rebalancing may experience difficulties in the initial commissioning of the system after TTR implementation. TTR (or TR) method costs could be minimized and benefit maximized if:

- Local control contractor labor rate is reasonable, and service quality is good.
- Mechanical system design is appropriate, and the system is operated as intended.
- Mechanical system has significant fan energy use.
- Problems with existing control system hardware and software are minimal.
- Incorporating the ability to ignore some rogue zones.

7.3 COST ANALYSIS AND COMPARISON

From Section 6.1.3, Table 16, it has been shown that among the five demonstration sites, overall first year costs for implementing TTR, training, and maintenance vary considerably from $1,671 to $10,661. Differences in cost are expected because the size, capacity of the HVAC systems and building control systems involved at the five sites were all different. While the lowest cost (Site #3) was due to a smaller HVAC system (only one roof top unit and 14 VAV terminal units), the highest cost (Site #4) was not the site with the largest building space and the most complicated HVAC system. The reason for the high cost at Site #4 is mainly due to its higher labor rate, and labor cost required for troubleshooting and fixing issues related to normal operation and control of the two AHUs and 66 VAV terminal units due to its older mechanical and building control system.

It is recommended that TTR/TR training can be included in existing facility engineer's routine professional training, be part of a new construction project delivery process, or be part of an onboarding training for new facility engineers. The TTR implementation, training, re-commissioning, and troubleshooting for rogue zone problems could also be implemented by a controls contractor who might be in the building for routine maintenance, lowering overall cost.

For cost-benefit analysis, please refer to Section 6.1.3 System Economics.

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8.0 REGULATIONS AND PERMITS REQUIRED

8.1 REGULATIONS AND PERMITS REQUIRED

For new construction, static pressure reset is a prescriptive requirement in ASHRAE Standard 90.1 when there is DDC control at the zone level. This requirement may also apply to significant HVAC additions or alterations, but otherwise generally does not apply to existing buildings. Minor control retrofits, including programming changes, generally do not require permitting.

There is no special permit required to implement the static pressure reset strategy.

8.2 PROCUREMENT ISSUES

Implementation of static pressure reset can be performed by a trained/qualified controls contractor or a building controls manufacturer with commercial, off-the-shelf building controls software. For VAV systems, only custom programming changes are required; no additional hardware is necessary. It is worth mentioning that different building control systems may have their proprietary control software or programming packages with various features and capabilities.

Hiring a good, qualified controls contractor with reasonable labor rate is the most important factor in making procurement decisions. Besides having programming expertise to use the proprietary building controls software or programming package, the selected controls contractor should also be knowledgeable on overall HVAC system control sequence and operations, as well as possess troubleshooting skills related to mechanical and control issues.

8.3 COMMISSIONING ISSUES

After custom programming of TTR by a controls contractor, commissioning of the TTR implementation should be completed to verify the TTR code runs as intended. Commissioning efforts should also include a review of setpoint reset strategies to check that the resets are operating effectively, tune them as necessary, and identify any potential rogue zones. The review should occur in different seasons or different weather conditions if possible. Any rogue zones identified should be investigated to determine the cause.

A sample TTR control sequence specification is shown in Appendix B. A TTR functional test form in Microsoft Excel Spreadsheet format was used in the TTR commissioning process and is shown in Appendix D.

During the demonstration, the following commissioning issues were encountered:

- Incorrectly implemented TTR sequence. One control manufacturer initially had difficulty correctly implementing the sequence. The main problem was that the proprietary programming tool (Logic Connector Tool from Johnson Controls) could not run at specific time intervals (e.g. once every 90 seconds). The problem was discovered during the functional testing. Eventually, the controls programmer found a workaround to fix the issue. Other controls contractors did not have problems implementing TTR.
- Control contractors needed training on how to conduct TTR functional test and fill out the functional test form.

- Initial TTR parameters, as suggested in the TTR specification, needed tuning to make the system work as intended. Early in the initial demonstration, instances of excessive static pressure oscillation were present in nearly all TTR days across each site. Static pressure control oscillated heavily with the initial TTR parameters showing cases of quick ramp-ups and downs in static pressure. TM and RP rates for all AHUs and RTUs were adjusted smaller and time interval for TTR program execution were extended. Because of this problem, the TTR method did not show advantage in terms of stability and ease of parameter tuning compared to traditional TR method.

During the commissioning of TTR, the most challenging and time-consuming tasks were identifying any potential rogue zones, troubleshooting the cause, and fixing the problems. Major issues can be categorized into three main categories: HVAC system design issues; building operations issues; mechanical and control hardware and software issues.

8.3.1 HVAC System Design Issues

In retrofit applications, the cost effectiveness of implementing static pressure reset may be improved if done in conjunction with other controls improvements and upgrades to take advantage of synergies with other measures and economies of scale with contractor programming and mobilization efforts. With DDC to the zone, typical retro-commissioning measures include demand-based supply air temperature and duct static pressure reset, dual maximum VAV logic with low VAV minimums, fixing faulty economizers and control valve leakage, and scheduling updates. In particular, low VAV minimum airflow setpoints has a direct impact on the savings potential for static pressure reset. Recent studies [Taylor, 2012] [Arens, 2015] [Kaam, 2017] have shown that VAV zones commonly spend a large percentage of time in deadband mode at minimum airflow setpoint. Unnecessarily high minimums may risk overcooling spaces and limit the turndown capability of the fans, which would reduce savings potential for static pressure reset.

Proper HVAC system design is one of the key factors in successful implementation of static pressure reset strategies. Improper system design not only can result in oversized or undersized equipment (AHU, RTU, VAV terminal units), but also noisy ducts, falling debris, and AHU shut down due to high static pressure. Some zones could be permanent “rogue” zones, making TTR method ineffective. For buildings with both VAV and radiant floor heating systems controlling the same zones, care should be taken in the control design of both systems, so simultaneous heating and cooling is minimized. For HVAC system retrofit during building additions and alterations, overall HVAC system modification design should be reviewed to make sure all VAV terminal units have the proper AHU supply air temperature and static pressure to handle zone heating and cooling loads.

Reset strategies that rely on zone demand should incorporate a mechanism to identify rogue zones or those zones that continuously drive the reset logic. Design should include monitoring graphics requirements (see Figure 68, 69 and 70) to include zone summary tables of all main zone parameters, including which zones are generating requests and their cumulative request-hours. Alarms should provide notification to operators of rogue zones. See ASHRAE Guideline 36 and Taylor [2015] for more information.

												Static Pressure Reset		
	Operating Mode	Airflow (CFM)	Airflow SP (CFM)	Zone Temp (°F)	Htg SP (°F)	Clg SP (°F)	Damper Pos (% Open)	HW Valve Pos (%Open)	DA Temp (°F)	DA Temp SP (°F)	CO2 Level (PPM)	Requests	Cumulative Req Hrs (%-req-hrs)	Importance Multiplier
VR-19-1	Deadband	342	330	73.3	71.0	74.0	29	0%	56.9	55.0	na	0	10%	1
VR-19-2	Cooling	278	280	73.9	71.0	74.0	31	0%	57.2	55.0	na	0	2%	1
VR-19-3	Cooling	275	279	73.1	70.0	73.0	24	0%	57.2	55.0	na	0	1%	1
VR-19-4	Deadband	245	235	72.9	71.0	74.0	16	0%	57.2	55.0	565	0	6%	1
VR-19-5	Deadband	184	180	72.3	71.0	74.0	25	0%	58.7	55.0	na	0	3%	1
VR-19-6	Cooling	1147	1144	70.8	68.0	71.0	45	0%	57.2	55.0	na	0	6%	1
VR-19-7	Deadband	102	100	73.0	71.0	74.0	32	0%	59.1	55.0	na	0	1%	1
VR-19-8	Deadband	252	250	72.9	71.0	74.0	41	0%	57.5	55.0	na	0	6%	1
VR-19-9	Deadband	508	500	73.1	72.0	75.0	15	0%	58.4	55.0	na	0	1%	1
VR-19-10	Deadband	308	300	72.4	71.0	74.0	31	0%	57.2	55.0	na	0	9%	1
VR-19-11	Deadband	290	270	73.5	71.0	74.0	32	0%	58.1	55.0	na	0	1%	1
VR-19-12	Deadband	368	360	74.3	72.0	75.0	11	0%	57.1	55.0	na	0	3%	1
VR-19-13	Deadband	512	500	73.7	71.0	74.0	32	0%	58.6	55.0	505	0	14%	1
VR-19-14	Cooling	673	675	73.8	71.0	74.0	54	0%	56.0	55.0	na	0	35%	1
VC-19-15	Deadband	97	90	72.5	71.0	74.0	17	na	na	na	na	0	0%	1
VC-19-16	Deadband	157	150	72.5	71.0	74.0	5	na	na	na	na	0	0%	1
VC-19-17	Deadband	165	150	72.5	71.0	74.0	17	na	na	na	na	0	0%	1
VC-19-18	Deadband	128	120	72.6	72.0	75.0	29	na	na	na	na	0	0%	1
VC-19-19	Deadband	127	120	72.2	71.0	74.0	28	na	na	na	na	0	0%	1
VC-19-20	Deadband	144	140	71.9	71.0	74.0	36	na	na	na	na	0	0%	1
VC-19-21	Deadband	138	135	73.7	71.0	74.0	26	na	na	na	na	0	0%	1
VC-19-22	Deadband	244	240	73.7	71.0	74.0	29	na	na	na	na	0	0%	1

Figure 68. Sample Zone Summary Graphic

Air Handler Run Hours

	HH:MM:SS
AHU-1 Run Hours	0:0:15

VAV Box Request Hours

	HH:MM:SS		HH:MM:SS		HH:MM:SS
VAV 101	0:0:0	VAV 113	0:0:0	VAV 125	0:0:0
VAV 102	0:0:0	VAV 114	0:0:0	VAV 126	0:0:0
VAV 103	0:0:0	VAV 115	0:0:0	VAV 127	0:0:0
VAV 104	0:0:0	VAV 116	0:0:0	VAV 128	0:0:0
VAV 105	0:0:0	VAV 117	0:0:0	VAV 129	0:0:0
VAV 106	0:0:0	VAV 118	0:0:0	VAV 130	0:0:0
VAV 107	0:0:0	VAV 119	0:0:0	VAV 131	0:0:15
VAV 108	0:0:0	VAV 120	0:0:0	VAV 132	0:0:0
VAV 109	0:0:0	VAV 121	0:0:0	VAV 133	0:0:0
VAV 110	0:0:0	VAV 122	0:0:0	VAV 134	0:0:0
VAV 111	0:0:0	VAV 123	0:0:0		
VAV 112	0:0:0	VAV 124	0:0:0		

Time accumulates when AHU is occupied and VAV damper is at 100% open.

To reset accumulated time manually reset at graphics button.

Request Reset true

Figure 69. Sample VAV Box Request Hours Summary Graphic #1

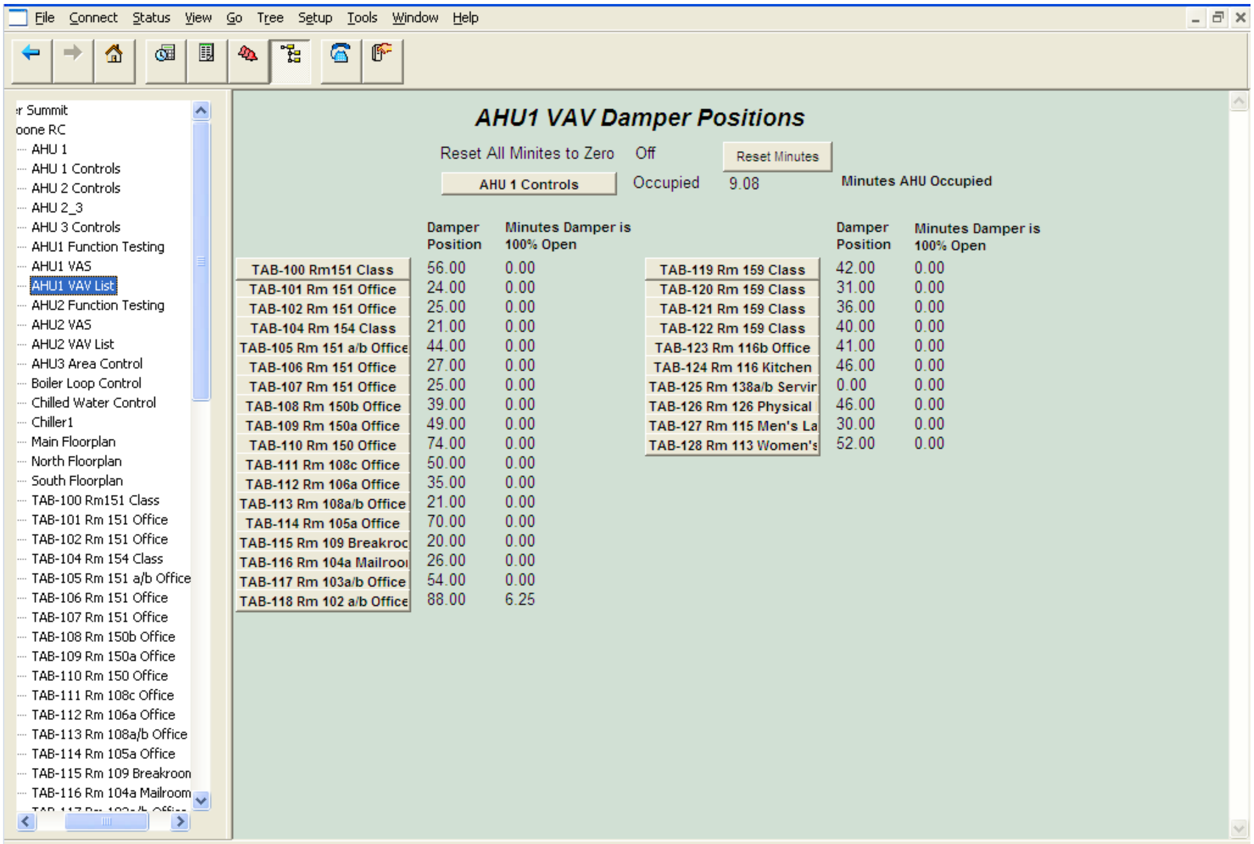

Figure 70. Sample VAV Box Request Hours Summary Graphic #2

In theory, static pressure reset strategy should work if HVAC system design is done properly and system operations run as intended. All zones should be controlled within design heating and cooling setpoints. In practice, perfect design and operation unfortunately almost never happen. Therefore, static pressure reset strategy should incorporate a user-adjustable mechanism to ignore certain zones from reset logic, whether specific individual zones are locked out, or there is a generic number of zones that can be ignored. Some practitioners use an importance multiplier and number of ignores described in Guideline 36 to accomplish both options. The importance multiplier also provides the ability to weight the demand more heavily in some zones than others.

Supply air temperature and duct static pressure control could affect each other. Operating with warmer supply air temperatures results in the need for more airflow, which may, in turn, impact the ability of the static pressure setpoint to reset. Resetting AHU supply air temperature based on Outside Air Temperature (OAT) may be problematic in that it is not a feedback-based control strategy, and OAT is not always representative of thermal load (e.g. interior zones not impacted by OAT).

Some practitioners suggest the AHU/RTU supply and return fan minimum speed should be set to no more than 10%, or to whatever makes the fan wheel turn when starting from a stop, in order to fully realize the potential fan power reductions during periods of low airflow. Many operators insist on maintaining a 20%~25% minimum speed to protect the motor from overheating.

The designer should take care to avoid creating excessively critical zones, e.g. a CAV zone that has a long duct run with high pressure drop.

The designer should also include graphics requirements showing a basic time-series trend graph of static pressure and setpoint to facilitate review of the reset operation by simple inspection and to remove the obstacle of requiring the operator to navigate through the front-end trend historians, which are often cumbersome to set up.

8.3.2 Building Operation Issues

HVAC system operation based on design intent is the second most important factor in effective static pressure reset implementations. Improper or irregular building operation often results in "rogue" zones. Operation issues such as:

- Boiler and chiller on/off not determined automatically based on actual building heating and cooling loads
- Airflow setpoints increased above design values
- Zone temperature setpoints set too low; setpoint adjustments should be limited in software
- Airflow restrictions (e.g. flex duct compressed, poorly designed fittings, undersized ducts, volume dampers incorrectly set, fire damper closed)
- Incorrect calibration factors at VAV box controllers
- AHU air-side economizer not working properly

Operators, especially DoD facility engineers, often do not have the time, expertise, or resources to monitor system performance for energy efficiency carefully. Typically, other issues such as addressing failed equipment, occupant complaints, and performing preventative maintenance take a higher priority. To ensure the systems continue to operate efficiently, alternative means to monitor performance should be considered, such as AFDD, energy monitoring dashboards that highlight performance degradation, advanced building analytics, or periodic re-commissioning.

8.3.3 Mechanical and Control Hardware and Software Issues

Mechanical and control hardware and software issues are other factors that could significantly reduce the effectiveness of static pressure reset. Issues such as:

- Old DDC systems may need to be upgraded. A downed network controller midway through the demonstration at Site #5, from January 2015 to April 2016, prolonged data collection for four months. A full upgrade of hardware and software was performed at this site as a result.
- Failed thermostats and VAV differential pressure sensors can lead to rogue zones, making pressure reset ineffective.
- Failed AHU economizer control can lead to high supply air temperature rogue zone problem as well.
- Building control network problem or interruption may prevent the TTR algorithm to run properly.
- Failed VFD drives can result in zone temperature out of control.

When these problems occur, mechanical or control contractors should be contacted for investigation and repair/replacement.

8.4 FACILITY ENGINEER TRAINING

Facility engineers should be trained to understand how the trim and respond reset is intended to operate and which settings are adjustable to maintain stability and balance energy efficiency with achieving setpoints. It is also desirable that facility engineers be trained to identify rogue zones and what to do about them. Ignoring some rogue zones may improve system reset performance but at the cost of further limiting airflow to those spaces, which results in poor zone temperature control. Care should be taken when applying temporary overrides to address short-term issues. Setpoint overrides should be done with an expiration, if possible, to avoid the risk of forgetting to restore to automatic control. Setpoint overrides can also often be reviewed through an audit feature in many control systems.

However, because of diverse backgrounds and experience with DDC, DoD facility engineers may or may not fully understand the theory or essence of the reset strategy and why it can save fan energy. Therefore, it is important for a controls contractor to create simple graphics (Figures 68 to 70) to identify rogue zones easily. The controls contractor should then be called to investigate the cause of the problem and recommend adjustments.

8.5 END-USER CONCERNS, RESERVATIONS, AND DECISION-MAKING FACTORS

For this demonstration, the only end-user concern was at one site where occupant experienced significant noise from AHU fans ramping up and down, debris falling from the ceiling, and temperature discomfort (due to AHU tripping on high static pressure) when AHU static pressure was running at or close to design setpoint. As discussed before, this was mainly due to HVAC system design flaws and improperly tuned TTR parameters. The facility engineer at this site had previously lowered the normal operating static pressure to a much lower value. There were no other significant complaints from occupants or facility engineers during the one-year demonstration period.

For new construction, static pressure reset is a prescriptive requirement in ASHRAE Standard 90.1 when there is DDC control at the zone level. This requirement may also apply to significant HVAC additions or alterations. Potential DoD fixed installation applications are in existing buildings that have VAV systems with zone-level DDC but are still using the fixed static pressure control strategy. From energy saving and system economic analysis results based on this demonstration, the decision-making factors regarding switching to static pressure reset strategy (either TTR or TR) could include:

- HVAC system design
- Local utility’s electricity rate
- Local controls contractor’s labor rate, service capability, and quality of work
- AHU/RTU system’s size and overall fans energy use
- Existing mechanical and building control systems’ condition, quality, and stability

- DoD facility engineer's familiarity with DDC system, time available to continue monitoring HVAC system's performance, and expertise to resolve related mechanical and control problems

From this demonstration project, the energy savings and system economics at the five IAARNG buildings are somewhat lower than previously estimated due to many factors. It is predicted that practitioners can find ways to improve the algorithm to make things work better in real buildings in the future. For example, by allowing some zones to be ignored from the reset strategy, the operator is implicitly sacrificing airflow and potentially temperature control in some spaces for minimizing energy use. Occupants often do not complain when zone temperatures are off a few degrees compared to setpoints. Automated Fault Detection and Diagnostics (AFDD) could be a useful tool for facility engineers and control contractors to quickly identify rogue zones and fix problems, maximizing energy and cost savings.

8.6 THE BEST DOD FIXED INSTALLATION APPLICATIONS

Based on the findings from the demonstration, the best DoD fixed installation applications for TTR method (or traditional TR method) in a building retrofit project would be a combination of the following:

- The majority of the HVAC systems are forced-air variable-air-volume systems with DDC control at the zone level. This method is not applicable to other HVAC systems such force-air constant-air-volume system, radiant heating and cooling system, heat pump system, fan coil units, unit ventilators, and chilled beam systems.
- Common applicable DoD fixed installation building types include Joint Forces Headquarters, medium or large offices, classrooms, auditoriums, reserve centers, and armories. Other building types such as apartments, multi-family housing, maintenance repair shops, warehouses, or motor vehicle storage buildings may be less applicable.
- The building's VAV systems have large AHU/RTU supply and return fans. The supply fan power is at least 3 horsepower at design condition.
- Local utility's average aggregated electricity rate is at or above the national average with at least more than 10~12 cents per kWh.
- Local controls contractor is reputable and reliable and offers reasonable field service rate (less than $120 per hour.)
- The building's VAV systems are well-maintained, commissioned, and operated as designed. The DDC system is not too old (less than ten years old) or obsolete.
- DoD facility engineers have a good understanding of how DDC system works, and have the capability of troubleshooting and fixing general AHU/RTU and VAV terminal unit mechanical and control problems.

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APPENDIX B TTR CONTROL SEQUENCE SPECIFICATION

1.1 Sequences of Operation

A. General

1. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.
2. When a control loop is enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a Neutral value.
3. A control loop in Neutral shall correspond to a condition which applies the minimum control effect, i.e. valves/dampers closed, VFDs at minimum speed, etc.
4. The term "proven" (i.e. "proven on"/ "proven off") shall mean that the equipment's DI status point matches the state set by the equipment's DO command point.
5. The term "control loop" or "loop" is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:

    Use of proportional-only prevents integral windup.

    a. Use of proportional-only prevents integral windup.

    Derivative terms make loop tuning difficult in practice.

    b. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.).

6. To avoid abrupt changes in equipment operation, the output of every control loop shall be limited to a maximum rate of change of 25% per minute unless otherwise noted.
7. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be capable of being adjusted by the operator through the normal EMCS user interface whether indicated as adjustable in sequences or not. Software (virtual) points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants (e.g. conversion factors).

All hardware points, not just inputs, should be capable of being overridden for purposes of testing and commissioning. For example, the commissioning agent should be able to command damper positions, valve positions, fan speeds, etc. directly through EMCS overrides.
The following requirement to equate hardware points to software points is necessary for systems that do not allow overriding real input points. Application Specific Controllers (ASC) are excepted because, in our experience, it may not be cost effective or feasible for all points due to limitations of ASC hardware. However, some critical points (e.g. VAV box damper position) may need to have this capability; these are specifically addressed in subsequent sequences.

8. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user (e.g. for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences. Exception: Not required for all ASC hardware points.

9. Tiered Trim & Respond Setpoint Reset Logic

   a. Tiered Trim & Respond setpoint reset logic for static pressure shall be implemented as described below.

   b. For each AHU static pressure setpoint controlled by a TT&R loop, define the following variables. All variables below shall be adjustable from a reset graphic accessible from a hyperlink on the associated system/plant graphic. Initial/default values are provided in subsequent paragraphs below.

Variable	Definition
SP_0	Initial setpoint, in wc
SP_{min}	Minimum setpoint, in wc
SP_{max}	Maximum setpoint, in wc
T_d	Delay timer, minutes
T	Time step, seconds
H1	High Threshold, Tier 1, percent Open
H2	High Threshold, Tier 2, percent Open
H3	High Threshold, Tier 3, percent Open
L1	Low Threshold, Tier 1, percent Open
L2	Low Threshold, Tier 2, percent Open
L3	Low Threshold, Tier 3, percent Open
TM1	Tier 1 Trim, in wc
TM2	Tier 2 Trim, in wc
TM3	Tier 3 Trim, in wc
RP1	Tier 1 Respond, in wc
RP2	Tier 2 Respond, in wc
RP3	Tier 3 Respond, in wc

   c. Tiered Trim & Respond logic shall reset setpoint within the range SPmin to SPmax. When the associated device (e.g. supply fan) is off, the setpoint shall be SP0. The reset logic shall be active while the associated device is proven on, starting Td after initial device start command. When TT&R logic is active, every time step T:

      i. The BAS shall compare the current position of all terminal unit dampers to determine the value of the Most-open Damper Position (MDP)

      ii. If the most open damper is less than the Tier 1 Low Threshold, adjust setpoint as follows (all adjustments are cumulative):

         1. If MDP < L1, decrease setpoint by TM1
         2. If MDP < L2, decrease setpoint by TM2
         3. If MDP < L3, decrease setpoint by TM3

iii. If the most open damper is greater than the Tier 1 High Threshold, adjust setpoint as follows (all adjustments are cumulative):
1. If MDP > H1, increase setpoint by RP1
2. If MDP > H2, increase setpoint by RP2
3. If MDP > H3, increase setpoint by RP3

iv. If the most open damper is between the Tier 1 Low Threshold and the Tier 1 High Threshold, leave setpoint unchanged.

d. For any given AHU, the initial/default values for TT&R logic shall be as follows:

Variable	Definition
SP_0	Average of SP_{min} and SP_{max}
SP_{min}	Per Engineer of Record
SP_{max}	Per Engineer of Record
T_d	10 minutes
T	Per Engineer of Record
H3	98%
H2	95%
H1	92%
L1	87%
L2	84%
L3	81%
TM1	See equation 0
TM2	2 * TM1 value
TM3	3 * TM1 value
RP1	See equation [2]
RP2	2 * RP1 value
RP3	3 * RP1 value

e. The default value of TM1 in “in wc” shall be calculated as follows

$$TM1 = \frac{T*(SP_{max} - SP_{min})}{900}$$ Equation [1]

f. The default value of RM1 in “in wc” shall be calculated as follows

$$RP1 = \frac{T*(SP_{max} - SP_{min})}{900}$$ Equation [2]

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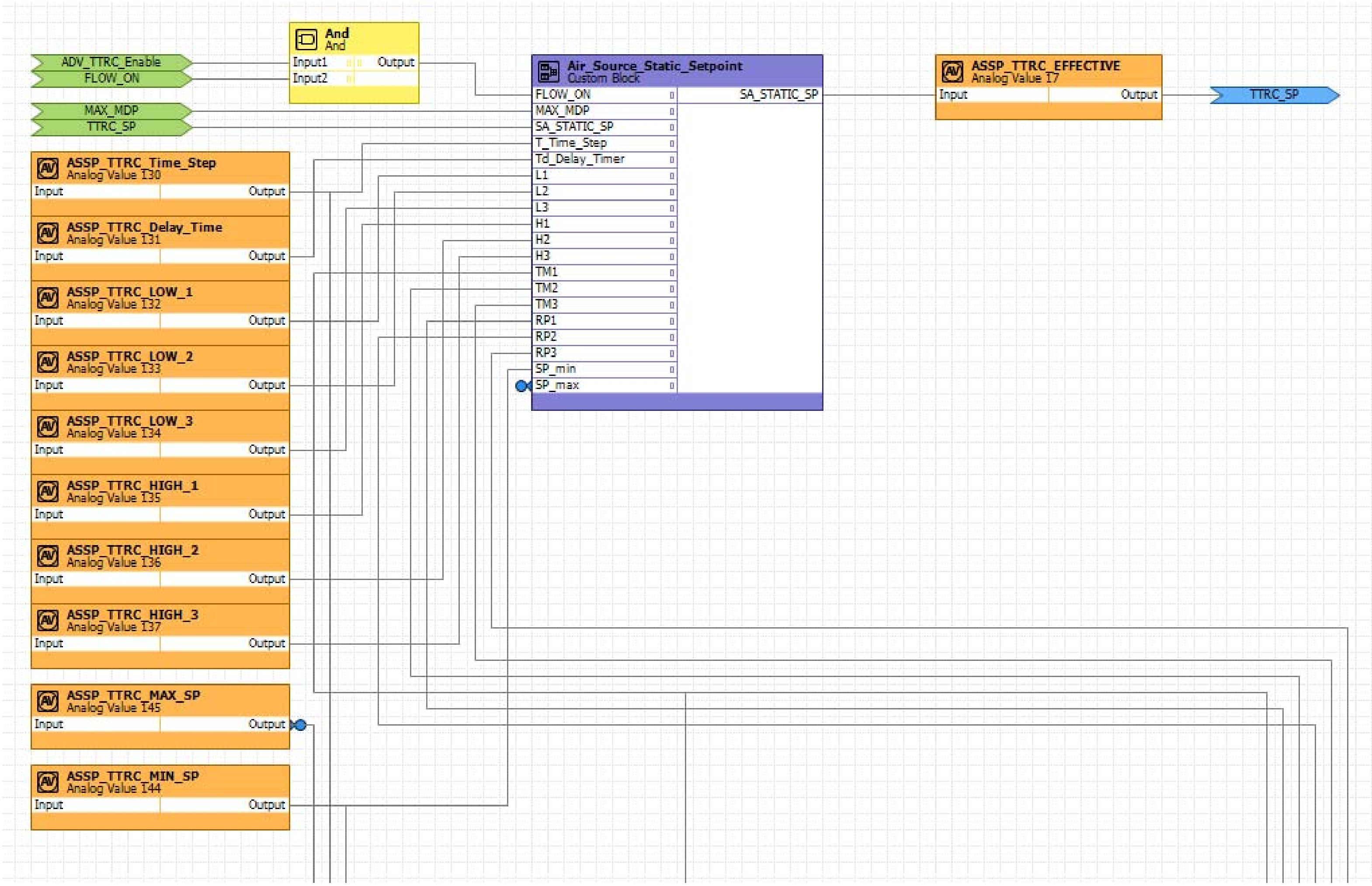
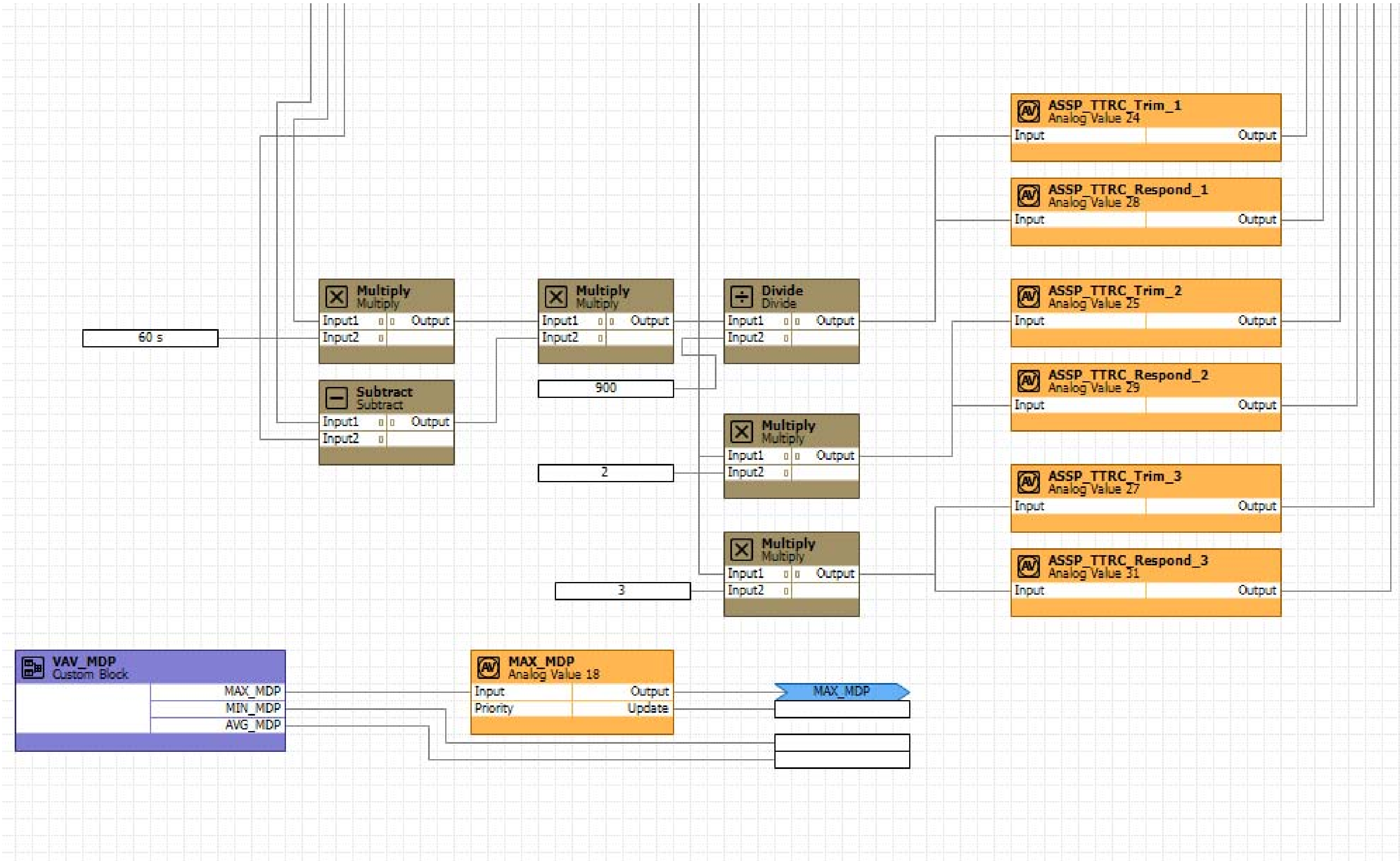
APPENDIX C TTR PROGRAM SAMPLES

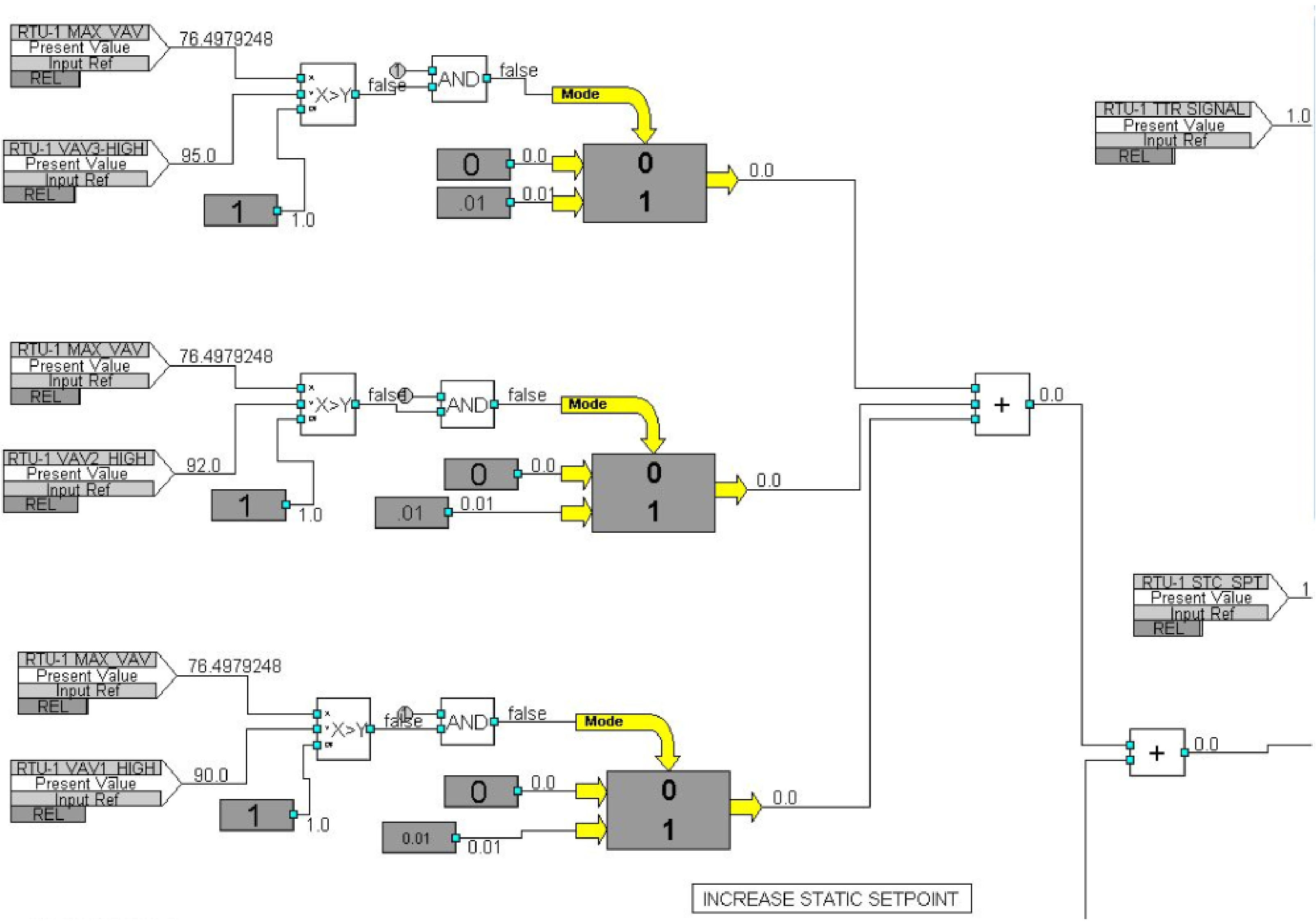
Site #1 – Distech Controls EC-Net^{AX}

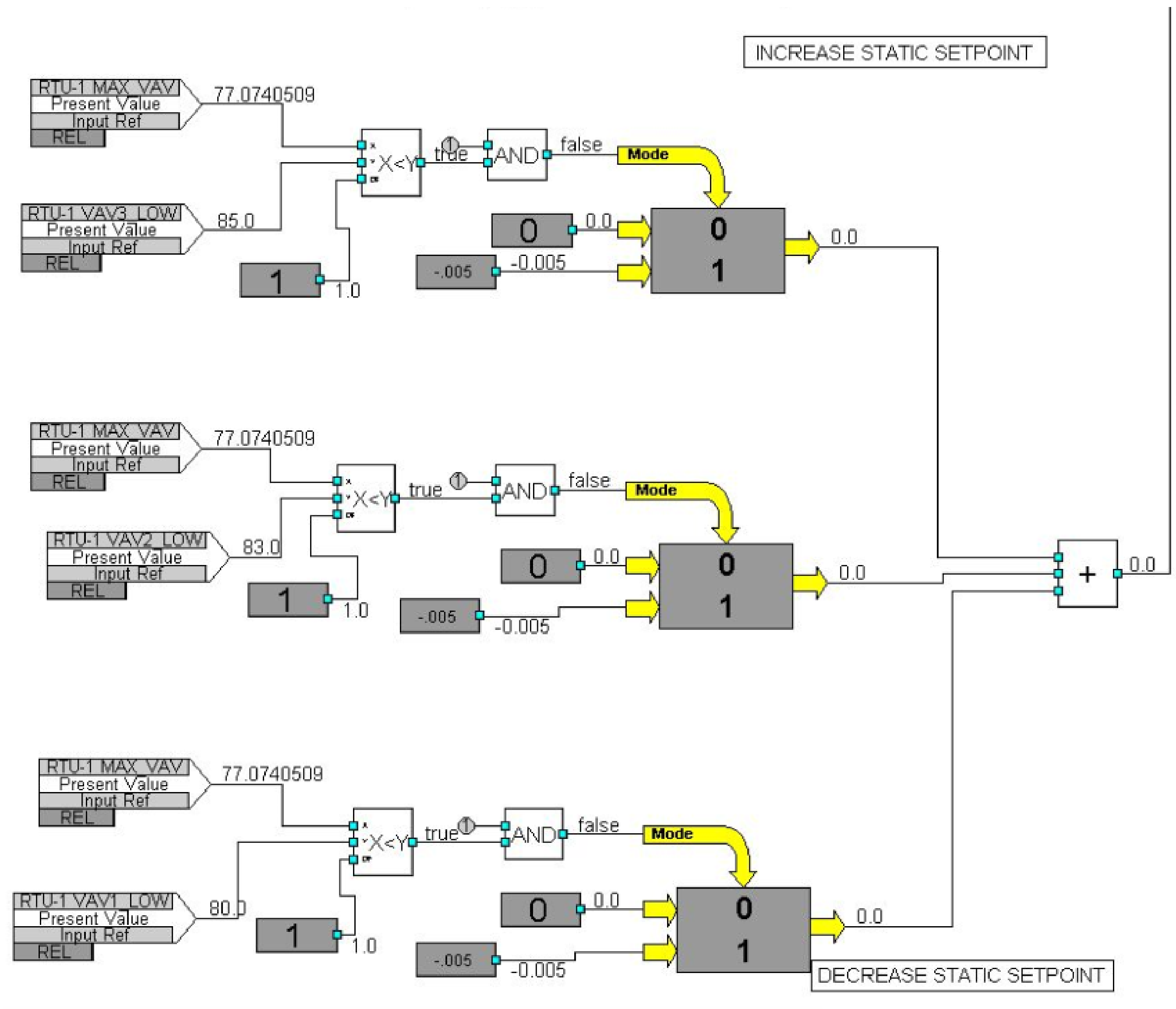




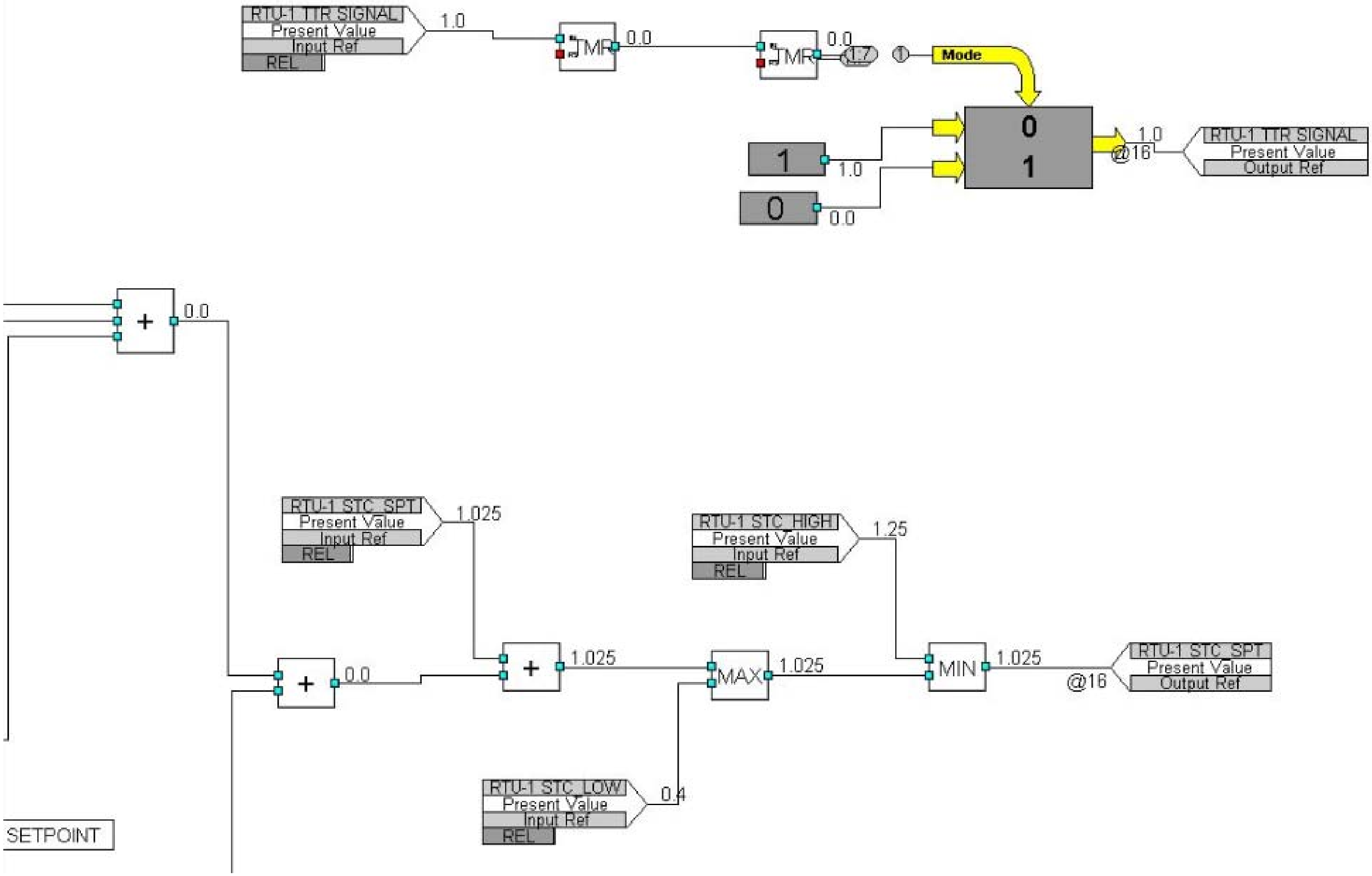
Multiply
Multiply
Input1
Output
Input2
60 s
Subtract
Subtract
Input1
Output
Input2
Multiply
Multiply
Input1
Output
Input2
900
2
3
Divide
Divide
Input1
Output
Input2
Multiply
Multiply
Input1
Output
Input2
Multiply
Multiply
Input1
Output
Input2
ASSP_TTRC_Trim_1
Analog Value 24
Input
Output
ASSP_TTRC_Respond_1
Analog Value 28
Input
Output
ASSP_TTRC_Trim_2
Analog Value 25
Input
Output
ASSP_TTRC_Respond_2
Analog Value 29
Input
Output
ASSP_TTRC_Trim_3
Analog Value 27
Input
Output
ASSP_TTRC_Respond_3
Analog Value 31
Input
Output
VAV_MDP
Custom Block
MAX_MDP
MIN_MDP
AVG_MDP
MAX_MDP
Analog Value 18
Input
Output
Priority
Update
MAX_MDP

Site #2 & #3 – Johnson Controls METASYS





INCREASE STATIC SETPOINT
RTU-1 MAX_VAV
Present Value
Input Ref
REL
77.0740509
RTU-1 VAV3_LOW
85.0
X<Y
true
AND
false
Mode
0
1
0.0
-.005
-0.005
1.0
RTU-1 VAV2_LOW
83.0
RTU-1 VAV1_LOW
80.0
+
DECREASE STATIC SETPOINT



RTU-1 TTR SIGNAL
Present Value
Input Ref
REL
1.0
TMR
0.0
TMR
0.0
Mode
0
1
1
1.0
0
0.0
1.0
@16
RTU-1 TTR SIGNAL
Present Value
Output Ref
+
0.0
RTU-1 STC_SPT
Present Value
Input Ref
REL
1.025
RTU-1 STC_HIGH
Present Value
Input Ref
REL
1.25
+
0.0
+
1.025
MAX
1.025
MIN
1.025
@16
RTU-1 STC_SPT
Present Value
Output Ref
RTU-1 STC_LOW
Present Value
Input Ref
REL
0.4
SETPOINT

Site #4 – Trane Tracer Summit

```
PROGRAM VAV_Critical_Zone_Reset_AHU_1

  DEFINT On=1, Up=1, i, startup_delay, reset_interval,
       ahu_status, ahu_timer, boxes=28, VAV1_Test_Damper_Position, VAV2_Test_Damper_Position,
       VAV3_Test_Damper_Position, Time_Step, Reset_Delay_Time, Normal, Occupy

  DEFFLT staticsp, maxpos, min_staticsp, initial_staticsp, max_staticsp,
       Teir1_Trim, Teir2_Trim, Teir3_Trim, RP_1, RP_2,
       RP_3, High_Threshold_Teir1, High_Threshold_Teir2, High_Threshold_Teir3, Low_Threshold_Teir1,
       Low_Threshold_Teir2, Low_Threshold_Teir3

  DEFOBJ setpoint, VAV[boxes]

  /// This routine calculates the static pressure setpoint for an air
  /// handling unit.  It resets the AHU static pressure setpoint based on
  /// a "critical zone".  VAV terminal units' maximum air valve position
  /// is determined, which is the basis for calculating an AHU static pressure
  /// setpoint. The AHU static pressure setpoint is adjusted to satisfy
  /// the critical zone, which inherently satisfies all other zones.
  /// Routine Execution:  This program is executed every 5 seconds.
  /// Routine Text File: VAV_Critical_Zone_Reset_AHU_1.CPL

  ahu_status = {AHU 1}.{Universal Input}[3] AND {AHU 1}.{Binary Out}[1]

  /// Might need to add the BOP for the supply fan

  min_staticsp = {AHU1 Supply Duct Static Min Stpt}.{Present Value}

  /// need added into summit
```

max_staticsp = {AHU1 Supply Duct Static Max Stpt}.{Present Value}

/// need added into summit

setpoint = {AHU1 Supply Duct Static Stpt}
/// this already existed need to make sure default is setup to normal operation

initial_staticsp = min_staticsp
Time_Step = {AHU1 Supply Duct Statc Time_Step}.{Present Value}

/// need added into summit

startup_delay = {AHU1 Supply Duct Static Time_Dly}.{Present Value}
High_Threshold_Teir1 = {AHU1 Duct High Thres Teir1}.{Present Value}

/// need added into summit

High_Threshold_Teir2 = {AHU1 Duct High Thres Teir2}.{Present Value}

/// need added into summit

High_Threshold_Teir3 = {AHU1 Duct High Thres Teir3}.{Present Value}

/// need added into summit

Low_Threshold_Teir1 = {AHU1 Duct Low Thres Teir1}.{Present Value}

/// need added into summit

Low_Threshold_Teir2 = {AHU1 Duct Low Thres Teir2}.{Present Value}

```
/// need added into summit

Low_Threshold_Teir3 = {AHU1 Duct Low Thres Teir3}.{Present Value}

/// need added into summit

reset_interval = Time_Step

/// The below VAV's are testing VAV's Change Object and Properties to choose other VAV's

VAV1_Test_Damper_Position = {TAB-100 Rm151 Class}.{Air Valve Position}
VAV2_Test_Damper_Position = {TAB-110 Rm 150 Office}.{Air Valve Position}
VAV3_Test_Damper_Position = {TAB-120 Rm 159 Class}.{Air Valve Position}
CONTROL ({AHU1 Duct Stpt VAV1 Damper Pos}, {Present Value}, VAV1_Test_Damper_Position, 16, SET)
VAV1_Test_Damper_Position = {AHU1 Duct Stpt VAV1 Damper Pos}.{Present Value}
CONTROL ({AHU1 Duct Stpt VAV2 Damper Pos}, {Present Value}, VAV2_Test_Damper_Position, 16, SET)
VAV2_Test_Damper_Position = {AHU1 Duct Stpt VAV2 Damper Pos}.{Present Value}
CONTROL ({AHU1 Duct Stpt VAV3 Damper Pos}, {Present Value}, VAV3_Test_Damper_Position, 16, SET)
VAV3_Test_Damper_Position = {AHU1 Duct Stpt VAV3 Damper Pos}.{Present Value}

///Setting up the Teir 1 - 3 Decrease static responses

Teir1_Trim = {AHU1 Duct Teir1 Trim}.{Present Value}
Teir2_Trim = Teir1_Trim * 2
Teir3_Trim = Teir1_Trim * 3
CONTROL ({AHU1 Duct Teir1 Trim}, {Present Value}, Teir1_Trim, 16, SET)

/// need added into summit

CONTROL ({AHU1 Duct Teir2 Trim}, {Present Value}, Teir2_Trim, 16, SET)
```

```
/// need added into summit

CONTROL ({AHU1 Duct Teir3 Trim}, {Present Value}, Teir3_Trim, 16, SET)

/// need added into summit

///Teir1_Trim = {AHU1 Duct Teir1 Trim}.{Present Value}

Teir2_Trim = {AHU1 Duct Teir2 Trim}.{Present Value}
Teir3_Trim = {AHU1 Duct Teir3 Trim}.{Present Value}

/// Setting up the ramp up static response

RP_1 = {AHU1 Duct Teir1 Respond}.{Present Value}
RP_2 = RP_1 * 2
RP_3 = RP_1 * 3
CONTROL ({AHU1 Duct Teir1 Respond}, {Present Value}, RP_1, 16, SET)

/// need added into summit

CONTROL ({AHU1 Duct Teir2 Respond}, {Present Value}, RP_2, 16, SET)

/// need added into summit

CONTROL ({AHU1 Duct Teir3 Respond}, {Present Value}, RP_3, 16, SET)

/// need added into summit

///RP_1 = {AHU1 Duct Teir1 Respond}.{Present Value}

RP_2 = {AHU1 Duct Teir2 Respond}.{Present Value}
RP_3 = {AHU1 Duct Teir3 Respond}.{Present Value}
Reset_Delay_Time = Local.{Saved Value}[1]
```

```
VAV[1] = {TAB-100 Rm151 Class}
VAV[2] = {TAB-101 Rm 151 Office}
VAV[3] = {TAB-102 Rm 151 Office}
VAV[4] = {TAB-104 Rm 154 Class}
VAV[5] = {TAB-105 Rm 151 a/b Office}
VAV[6] = {TAB-106 Rm 151 Office}
VAV[7] = {TAB-107 Rm 151 Office}
VAV[8] = {TAB-108 Rm 150b Office}
VAV[9] = {TAB-109 Rm 150a Office}
VAV[10] = {TAB-110 Rm 150 Office}
VAV[11] = {TAB-111 Rm 108c Office}
VAV[12] = {TAB-112 Rm 106a Office}
VAV[13] = {TAB-113 Rm 108a/b Office}
VAV[14] = {TAB-114 Rm 105a Office}
VAV[15] = {TAB-115 Rm 109 Breakroom}
VAV[16] = {TAB-116 Rm 104a Mailroom}
VAV[17] = {TAB-117 Rm 103a/b Office}
VAV[18] = {TAB-118 Rm 102 a/b Office}
VAV[19] = {TAB-119 Rm 159 Class}
VAV[20] = {TAB-120 Rm 159 Class}
VAV[21] = {TAB-121 Rm 159 Class}
VAV[22] = {TAB-122 Rm 159 Class}
VAV[23] = {TAB-123 Rm 116b Office}
VAV[24] = {TAB-124 Rm 116 Kitchen}
VAV[25] = {TAB-125 Rm 138a/b Serving}
VAV[26] = {TAB-126 Rm 126 Physical Fitnes}
VAV[27] = {TAB-127 Rm 115 Men's Latrine}
VAV[28] = {TAB-128 Rm 113 Women's Latrine}

/// Steve to verify reset_Interval

ahu_timer = MAX(Local.{Saved Value}[16], 0)
IF (ahu_status = On)
```

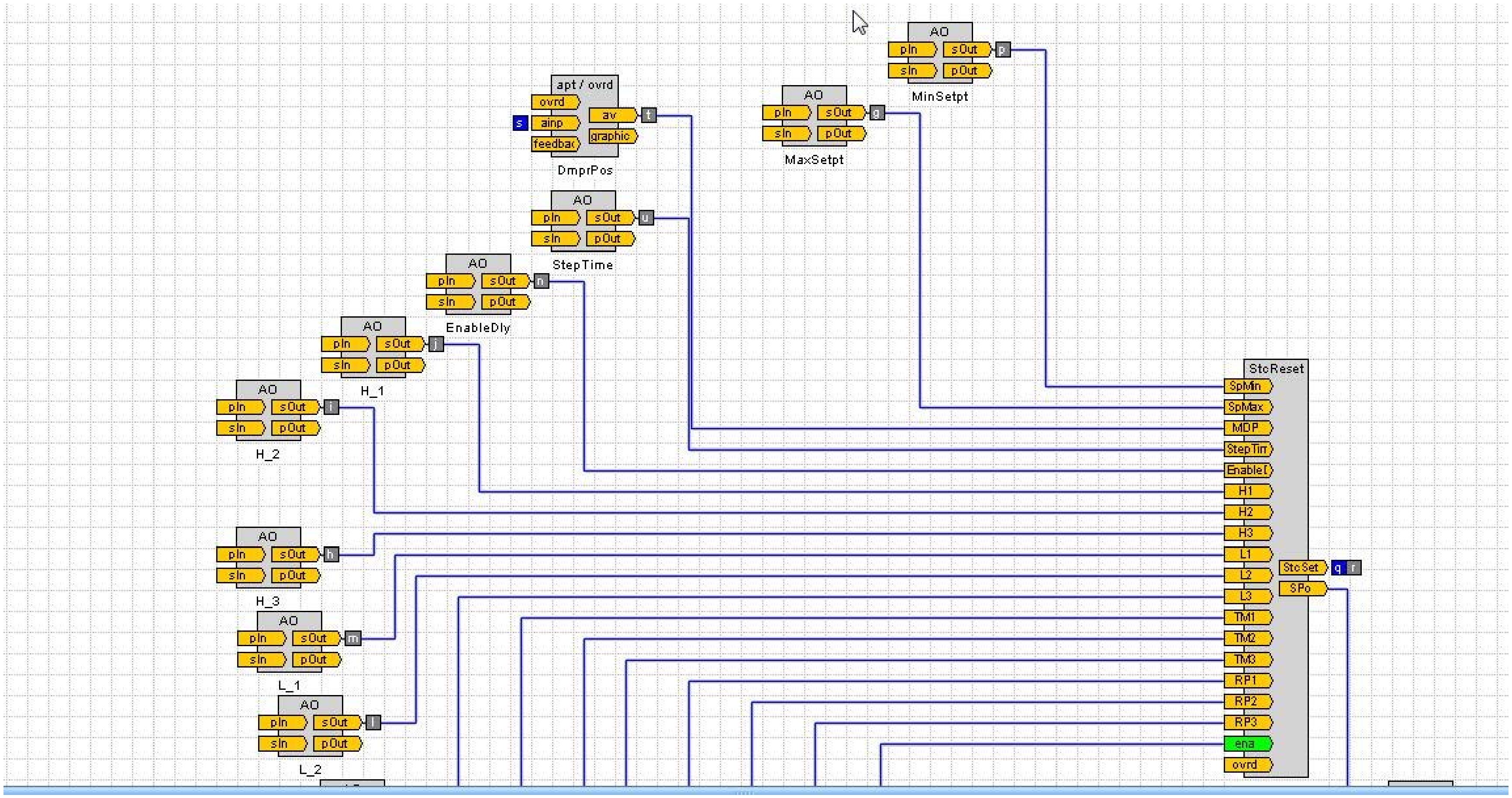
```
THEN
  ahu_timer = ahu_timer + 5
ELSE
  Local.{Saved Value}[16] = 0
  IF ((setpoint.{Present Value} <> initial_staticsp) AND ({Enable AHU1 Trim and Response}.{Present Value} = On))
  THEN
    CONTROL (setpoint, {Present Value}, initial_staticsp, 16, SET)
  ELSE
    CONTROL (setpoint, {Present Value}, initial_staticsp, 16, RELEASE)
  END IF
  STOP
END IF
Local.{Saved Value}[16] = ahu_timer
IF ((Reset_Delay_Time >= reset_interval) AND (ahu_timer > (startup_delay * 60)))
THEN
  Reset_Delay_Time = 0

/// below will look at all communicating VAVs and setup the max damper position

/// Local Saved Value 2 should give you the name of the Max Position box except in test mode

  maxpos = 0
  FOR i = 1 TO boxes
    IF (VAV[i].{Communication State} = Up)
    THEN
      IF (VAV[i].{Air Valve Position} > maxpos)
      THEN
        maxpos = VAV[i].{Air Valve Position}
        Local.{Saved Value}[2] = VAV[i].{Object Name}
      END IF
    END IF
  NEXT
ELSE
```

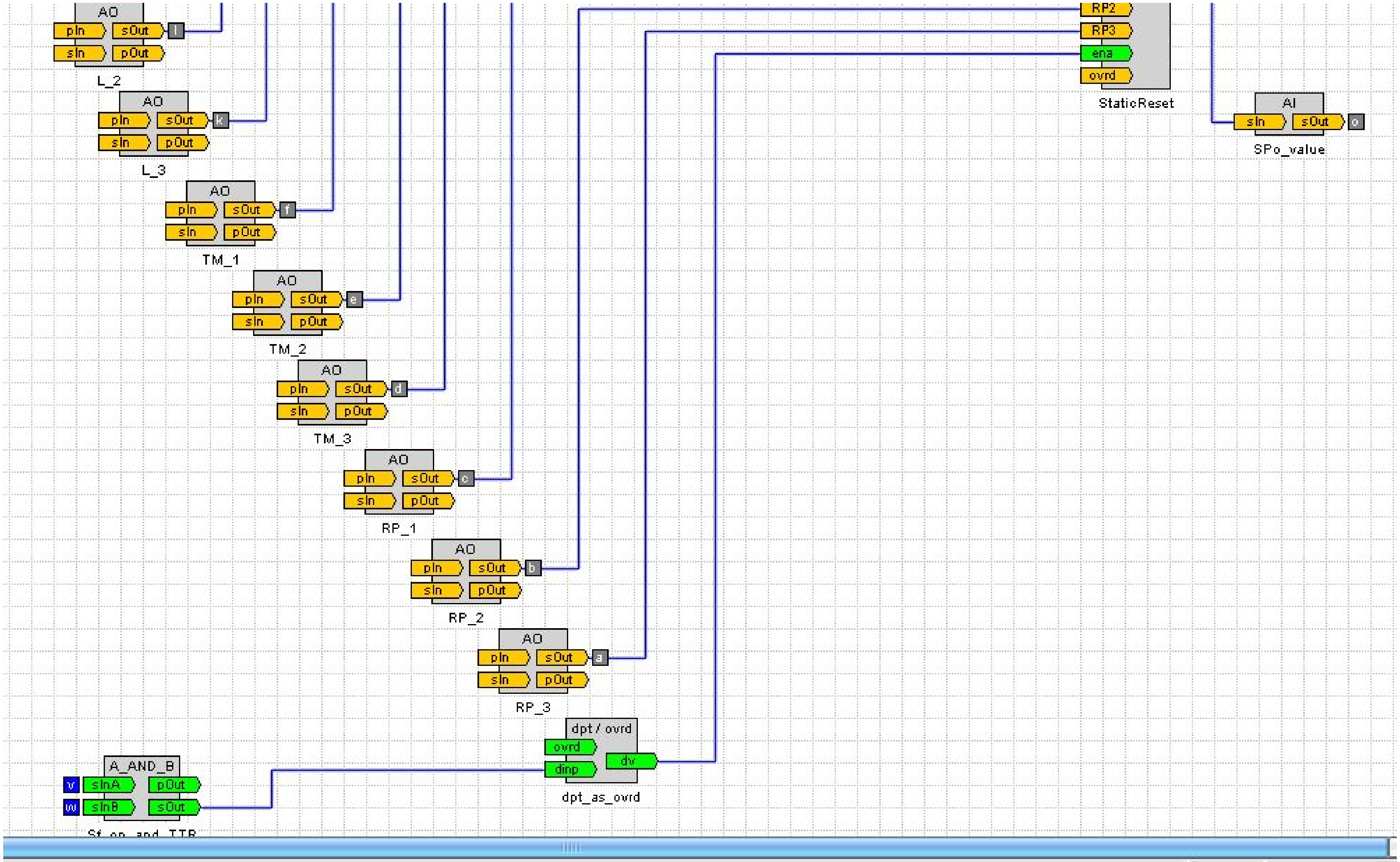
```
  Reset_Delay_Time = Reset_Delay_Time + 5
  Local.{Saved Value}[1] = Reset_Delay_Time
  STOP
END IF
Local.{Saved Value}[3] = maxpos
IF (VAV1_Test_Damper_Position > maxpos)
THEN
  maxpos = VAV1_Test_Damper_Position
END IF
IF (VAV2_Test_Damper_Position > maxpos)
THEN
  maxpos = VAV2_Test_Damper_Position
END IF
IF (VAV3_Test_Damper_Position > maxpos)
THEN
  maxpos = VAV3_Test_Damper_Position
END IF
staticsp = setpoint.{Present Value}
/// Below will increase the static setpoint if the mas exceeds the high teirs

IF (maxpos <> 0.000000)
THEN
  IF (maxpos > High_Threshold_Teir1)
  THEN
    staticsp = staticsp + RP_1
  END IF
  IF (maxpos > High_Threshold_Teir2)
  THEN
    staticsp = staticsp + RP_2
  END IF
  IF (maxpos > High_Threshold_Teir3)
  THEN
    staticsp = staticsp + RP_3
```

```
  END IF

/// Below will decrease the static pressure if the max damper is lower than the teirs

  IF (maxpos < Low_Threshold_Teir1)
  THEN
    staticsp = staticsp - Teir1_Trim
  END IF
  IF (maxpos < Low_Threshold_Teir2)
  THEN
    staticsp = staticsp - Teir2_Trim
  END IF
  IF (maxpos < Low_Threshold_Teir3)
  THEN
    staticsp = staticsp - Teir3_Trim
  END IF
ELSE
  staticsp = initial_staticsp

/// This is Min_Static_Stpt


END IF
staticsp = MIN(staticsp, max_staticsp)
staticsp = MAX(staticsp, min_staticsp)

/// Only allow the static pressure to change if the trim and response is enables

/// need to verify that 1 equals "Enabled"
```

```
  IF ((setpoint.{Present Value} <> staticsp) AND ({Enable AHU1 Trim and Response}.{Present Value} = 1))
  THEN
    CONTROL (setpoint, {Present Value}, staticsp, 16, SET)
    staticsp = Local.{Saved Value}[15]
  END IF
  IF ({Enable AHU1 Trim and Response}.{Present Value} = 0)
  THEN
    CONTROL (setpoint, {Present Value}, staticsp, 16, RELEASE)
  END IF
  Local.{Saved Value}[1] = Reset_Delay_Time

END
```

Site #5 – TAC/Invensys IA Series




AO
pIn
sOut
sIn
pOut
L_2
L_3
TM_1
TM_2
TM_3
RP_1
RP_2
RP_3
RP2
RP3
ena
ovrd
StaticReset
AI
SPo_value
dpt / ovrd
dinp
dv
dpt_as_ovrd
A_AND_B
sInA
sInB

```
// --------------------INPUTS--------------------
INPUT           FLOATSTATUSTYPE           SPMIN
INPUT           FLOATSTATUSTYPE           SPMAX
INPUT           FLOATSTATUSTYPE           MDP
INPUT           FLOATSTATUSTYPE           STEPTIME
INPUT           FLOATSTATUSTYPE           ENABLEDELAY

INPUT           FLOATSTATUSTYPE           H1
INPUT           FLOATSTATUSTYPE           H2
INPUT           FLOATSTATUSTYPE           H3
INPUT           FLOATSTATUSTYPE           L1
INPUT           FLOATSTATUSTYPE           L2
INPUT           FLOATSTATUSTYPE           L3

INPUT           FLOATSTATUSTYPE           TM1
INPUT           FLOATSTATUSTYPE           TM2
INPUT           FLOATSTATUSTYPE           TM3

INPUT           FLOATSTATUSTYPE           RP1
INPUT           FLOATSTATUSTYPE           RP2
INPUT           FLOATSTATUSTYPE           RP3

INPUT           BOOLEANSTATUSTYPE         ENA
COMMANDABLE INPUT FLOATPRIORITYTYPE           OVRD

// -------------------OUTPUTS--------------------
OUTPUT                  FLOATSTATUSTYPE           STCSET
OUTPUT                  FLOATSTATUSTYPE           SPO



// ------------------VARIABLES-------------------

PERSISTENT      FLOATSTATUSTYPE           DCTSTCSET
                DATETIMETYPE              LASTCHANGETIME = CURRENTDATETIME
                DATETIMETYPE              LASTENABLETIME = CURRENTDATETIME
                DATETIMETYPE              LASTEXECTIME = CURRENTDATETIME

                FLOATSTATUSTYPE           SPAVG
```

```
        FLOATSTATUSTYPE         ONDLY

        FLOATSTATUSTYPE         TM1
        FLOATSTATUSTYPE         TM2
        FLOATSTATUSTYPE         TM3

        FLOATSTATUSTYPE         RP1
        FLOATSTATUSTYPE         RP2
        FLOATSTATUSTYPE         RP3


// -------------------PROPERTIES-------------------


// --------------------BODY----------------------

// INITIALIZE VALUE

TM1.VALUE = TM1.VALUE
TM2.VALUE = TM1.VALUE + TM2.VALUE
TM3.VALUE = TM1.VALUE + TM2.VALUE + TM3.VALUE

RP1.VALUE = RP1.VALUE
RP2.VALUE = RP1.VALUE + RP2.VALUE
RP3.VALUE = RP1.VALUE + RP2.VALUE + RP3.VALUE

SPAVG.VALUE = (SPMAX.VALUE + SPMIN.VALUE) / 2
SPO.VALUE = SPAVG.VALUE

ONDLY.VALUE = ENABLEDELAY.VALUE * 60


// EVERY X SECONDS INCREMENT OR DECREMENT STATIC SP BASED ON REMOTE DAMPER DEVIATION FROM SET
    IF DELTA(LASTENABLETIME,CURRENTDATETIME) >= ONDLY.VALUE
    IF DELTA(LASTCHANGETIME,CURRENTDATETIME) >= STEPTIME.VALUE

            IF MDP.VALUE < L3.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE - TM3.VALUE
                    LASTCHANGETIME = CURRENTDATETIME
```

```
        ELSE
            IF MDP.VALUE < L2.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE - TM2.VALUE
                    LASTCHANGETIME = CURRENTDATETIME
        ELSE

            IF MDP.VALUE < L1.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE - TM1.VALUE
                    LASTCHANGETIME = CURRENTDATETIME
        ELSE

            IF MDP.VALUE > H3.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE + RP3.VALUE
                    LASTCHANGETIME = CURRENTDATETIME
        ELSE

            IF MDP.VALUE > H2.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE + RP2.VALUE
                    LASTCHANGETIME = CURRENTDATETIME
        ELSE

            IF MDP.VALUE > H1.VALUE
                    DCTSTCSET.VALUE = STCSET.VALUE + RP1.VALUE
                    LASTCHANGETIME = CURRENTDATETIME

                            ENDIF
                        ENDIF
                    ENDIF
                ENDIF
            ENDIF
        ENDIF
    ENDIF
ENDIF

// PREVENT STATIC SETPOINT FROM GOING BEYOND ITS LIMIT AND SET OUTPUT
    IF DCTSTCSET.VALUE > SPMAX.VALUE
        DCTSTCSET = SPMAX
    ENDIF
    IF DCTSTCSET.VALUE < SPMIN.VALUE
        DCTSTCSET = SPMIN
```

```
          ENDIF

/* IF THE AHU IS DISABLED AND THERE IS NO AHU STATUS
   SET THE STATIC SETPOINT BACK TO ITS AVERAGE. */

          IF ENA.VALUE == FALSE
                    DCTSTCSET = SPAVG
          ENDIF
/* ENABLE DELAY. */

          IF ENA.VALUE == FALSE
          LASTENABLETIME = CURRENTDATETIME
ENDIF

/* IF THE OBJECT IS OVERRIDDEN, IGNORE THE STATIC SETPOINT CALCULATED
   ABOVE AND USE THE OVERRIDE NUMBERS. */
          SETOVERRIDDEN(FALSE)
          DCTSTCSET.STATUS.OVERRIDDEN = FALSE
IF        OVRD.PRIORITY == CONTROLPRIORITYENUM.LEVEL_1
          SETOVERRIDDEN(TRUE)
          DCTSTCSET.VALUE = OVRD.VALUE
          DCTSTCSET.STATUS.OVERRIDDEN = TRUE
ENDIF

STCSET = DCTSTCSET
```

APPENDIX D TTR FUNCTIONAL TEST FORM SAMPLE

Test Sequence for Tiered Trim & Respond

Please be sure to indicate the DATE, TIME, and PASS/FAIL status of the test in each case.

Some cell values are used for calculations elsewhere in the test. These cells are highlighted.

Technician Name:	**John J Hamilton**
Tested Equipment Tag(s):	**VA1, VA2,VA3**
Last Test Completed at:	#N/A

Step #	Test	Expected Response	Observed Response		Comments	Pass?
A. Tiered Trim & Respond Setpoint Reset Test						
1	Record TT&R parameters. Randomly select three VAV boxes, designated A, B, and C, and record their tags. Override all VAV box damper position signals (spoof input to EMCS) to a neutral value of 90%.	None	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:10:11 AM**		
			SPmin value (inches H2O)	**0.70**		
			SPmax value (inches H2O)	**1.60**		
			SPo value (inches H2O)	**1.60**		
			TT&R loop cycle time T (in SECONDS)	**90**		
			VAV-A tag	**VA1**		
			VAV-B tag	**VA2**		
			VAV-C tag	**VA3**		
2	Verify trim values and response values. Verify overridden damper position signals for VAV A, B, and C. Do NOT override TT&R loop cycle timer. That value is a key part of the calculations.	TM1, TM2, and TM3 match expectation per sequences. RM1, RM2, and RM3 match expectation per sequences.	Date: Insert Date & Time	**5/12/2015**	Manually changed these values as no default values was calculated in the TTR program.	Yes
			Time:	**11:12:51 AM**		
			TM1 = 0.09 inches H2O (Y/N)	**Y**		
			TM2 = 0.18 inches H2O (Y/N)	**Y**		
			TM3 = 0.27 inches H2O (Y/N)	**Y**		
			RP1 = 0.09 inches H2O (Y/N)	**Y**		
			RP2 = 0.18 inches H2O (Y/N)	**Y**		
			RP3 = 0.27 inches H2O (Y/N)	**Y**		
			VAV-A damper position signal %	**90**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
3	Initialize TT&R control loop. Wait 90 seconds.	Setpoint remains unchanged at SPo	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:19:12 AM**		
			Setpoint after 90 seconds is 1.6 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.60**		
4	Override setpoint to minimum value of 0.7 in H2O Wait 90 seconds.	Setpoint remains unchanged at Spmin	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:19:50 AM**		
			Setpoint after 90 seconds is 0.7 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**0.70**		

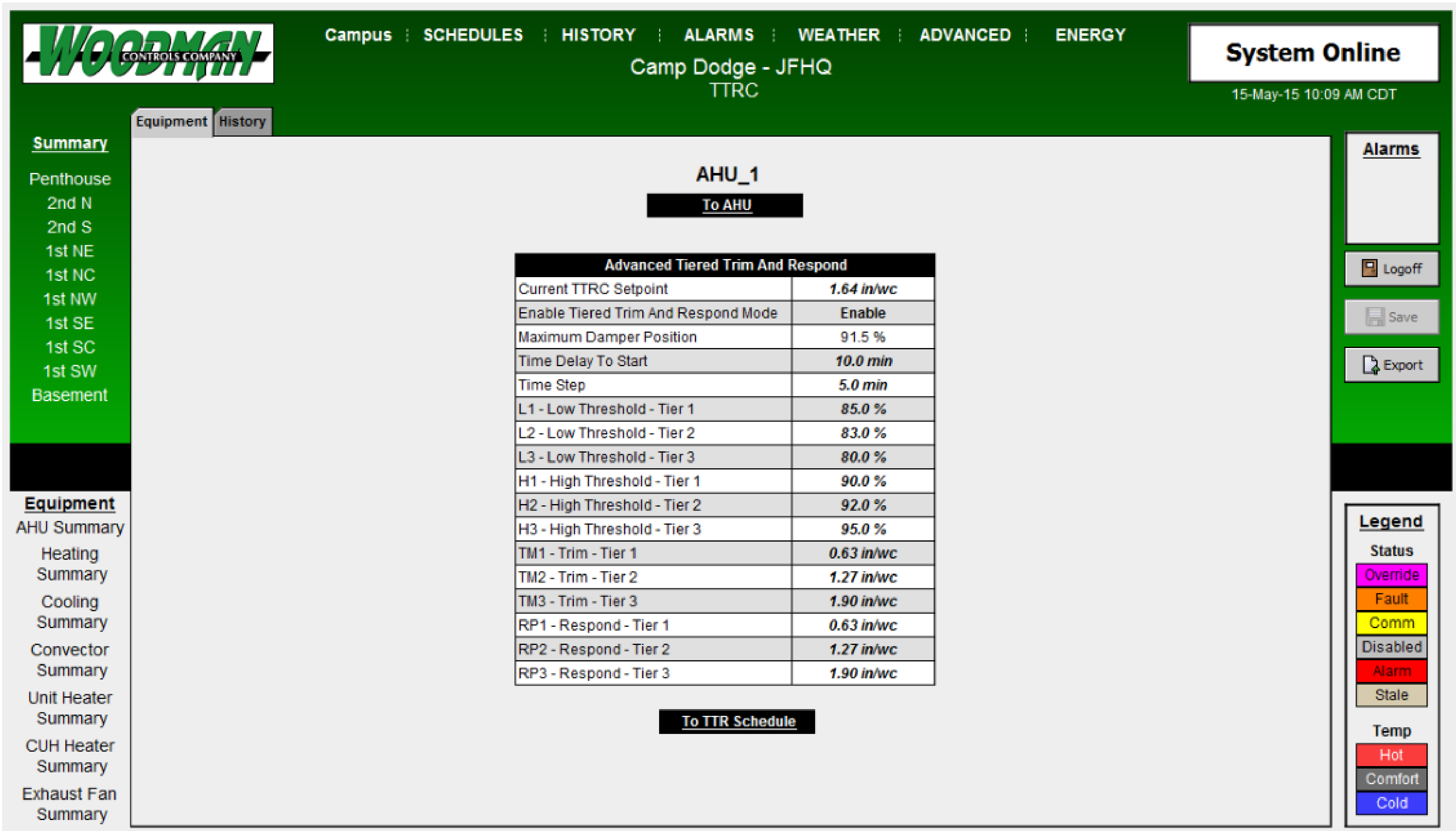
5	Override VAV damper signals as follows: VAV-A to 93% (others unchanged) Wait 90 seconds.	Setpoint increases by 0.09 in H2O, or increases to 1.6 in H2O, whichever is less.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:26:31 AM**		
			VAV-A damper position signal %	**93**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
			Setpoint after 90 seconds is 0.79 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.06**		
6	Override VAV damper signals as follows: VAV-B to 96% (others unchanged) Wait 90 seconds.	Setpoint increases by 0.27 in H2O, or increases to 1.6 in H2O, whichever is less.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:29:13 AM**		
			VAV-A damper position signal %	**93**		
			VAV-B damper position signal %	**96**		
			VAV-C damper position signal %	**90**		
			Setpoint after 90 seconds is 1.33 inches H2O (Y/N)			
			Setpoint at start of next step equals	**1.33**		
7	Override VAV damper signals as follows: VAV-C to 99% (others unchanged) Wait 90 seconds.	Setpoint increases by 0.54 in H2O, or increases to 1.6 in H2O, whichever is less.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:42:20 AM**		
			VAV-A damper position signal %	**93**		
			VAV-B damper position signal %	**96**		
			VAV-C damper position signal %	**99**		
			Setpoint after 90 seconds is 1.6 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.60**		
8	Wait for setpoint to increase to equal 1.6 inches H2O. Note number of time cycles required to reach this condition. Wait at least one additional cycle to verify that setpoint does not change.	Setpoint increases to 1.6 inches H2O and then stops changing.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:43:44 AM**		
			VAV-A damper position signal %	**93**		
			VAV-B damper position signal %	**96**		
			VAV-C damper position signal %	**99**		
			Setpoint equals 1.6 inches H2O (Y/N)	**Y**		
			Setpoint never exceeds 1.6 inches H2O (Y/N)	**Y**		
			Setpoint achieves 1.6 inches H2O in no more than 0 cycles (0 seconds) from last step (Y/N)	**Y**		
9	Override VAV damper signals as follows: VAV-A to 90% VAV-B to 90% VAV-C to 90% (others unchanged) Wait 180 seconds (two cycles).	Setpoint remains unchanged at 1.6 inches H2O.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:45:28 AM**		
			VAV-A damper position signal %	**90**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
			Setpoint equals 1.6 inches H2O (Y/N)	**Y**		
			Setpoint never exceeds 1.6 inches H2O (Y/N)	**Y**		
			Setpoint never dips below 1.6 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.60**		

9	Override VAV damper signals as follows: VAV-A to 86% VAV-B to 83% VAV-C to 80% (others unchanged) Wait 90 seconds.	Setpoint decreases by -0.09 in H2O, or decreases to 0.7 in H2O, whichever is greater.	Date: Insert Date & Time	**5/12/2015**	Overide all other VAV box damper% to 70% first.	Yes
			Time:	**11:49:16 AM**		
			VAV-A damper position signal %	**86**		
			VAV-B damper position signal %	**83**		
			VAV-C damper position signal %	**80**		
			Setpoint after 90 seconds is 1.51 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.51**		
10	Override VAV damper signals as follows: VAV-A to 50% (others unchanged) Wait 90 seconds.	Setpoint decreases by -0.27 in H2O, or decreases to 0.7 in H2O, whichever is greater.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:54:46 AM**		
			VAV-A damper position signal %	**50**		
			VAV-B damper position signal %	**83**		
			VAV-C damper position signal %	**80**		
			Setpoint after 90 seconds is 1.24 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.24**		
11	Override VAV damper signals as follows: VAV-B to 50% (others unchanged) Wait 90 seconds.	Setpoint decreases by -0.54 in H2O, or decreases to 0.7 in H2O, whichever is greater.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:56:21 AM**		
			VAV-A damper position signal %	**50**		
			VAV-B damper position signal %	**50**		
			VAV-C damper position signal %	**80**		
			Setpoint after 90 seconds is 0.7 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**0.70**		
12	Wait for setpoint to decrease to equal 0.7 inches H2O. Note number of time cycles required to reach this condition. Wait at least one additional cycle to verify that setpoint does not change.	Setpoint decreases to 0.7 inches H2O and then stops changing.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:58:09 AM**		
			VAV-A damper position signal %	**50**		
			VAV-B damper position signal %	**50**		
			VAV-C damper position signal %	**80**		
			Setpoint equals 0.7 inches H2O (Y/N)	**Y**		
			Setpoint never goes below 0.7 inches H2O (Y/N)	**Y**		
			Setpoint achieves 0.7 inches H2O in no more than 2 cycles (180 seconds) from last step (Y/N)	**Y**		
13	Override VAV damper signals as follows: VAV-A to 90% VAV-B to 90% VAV-C to 90% (others unchanged) Wait 180 seconds (two cycles).	Setpoint remains unchanged at 0.7 inches H2O.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**11:59:08 AM**		
			VAV-A damper position signal %	**90**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
			Setpoint equals 0.7 inches H2O (Y/N)	**Y**		
			Setpoint never exceeds 0.7 inches H2O (Y/N)	**Y**		
			Setpoint never dips below 0.7 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**0.70**		

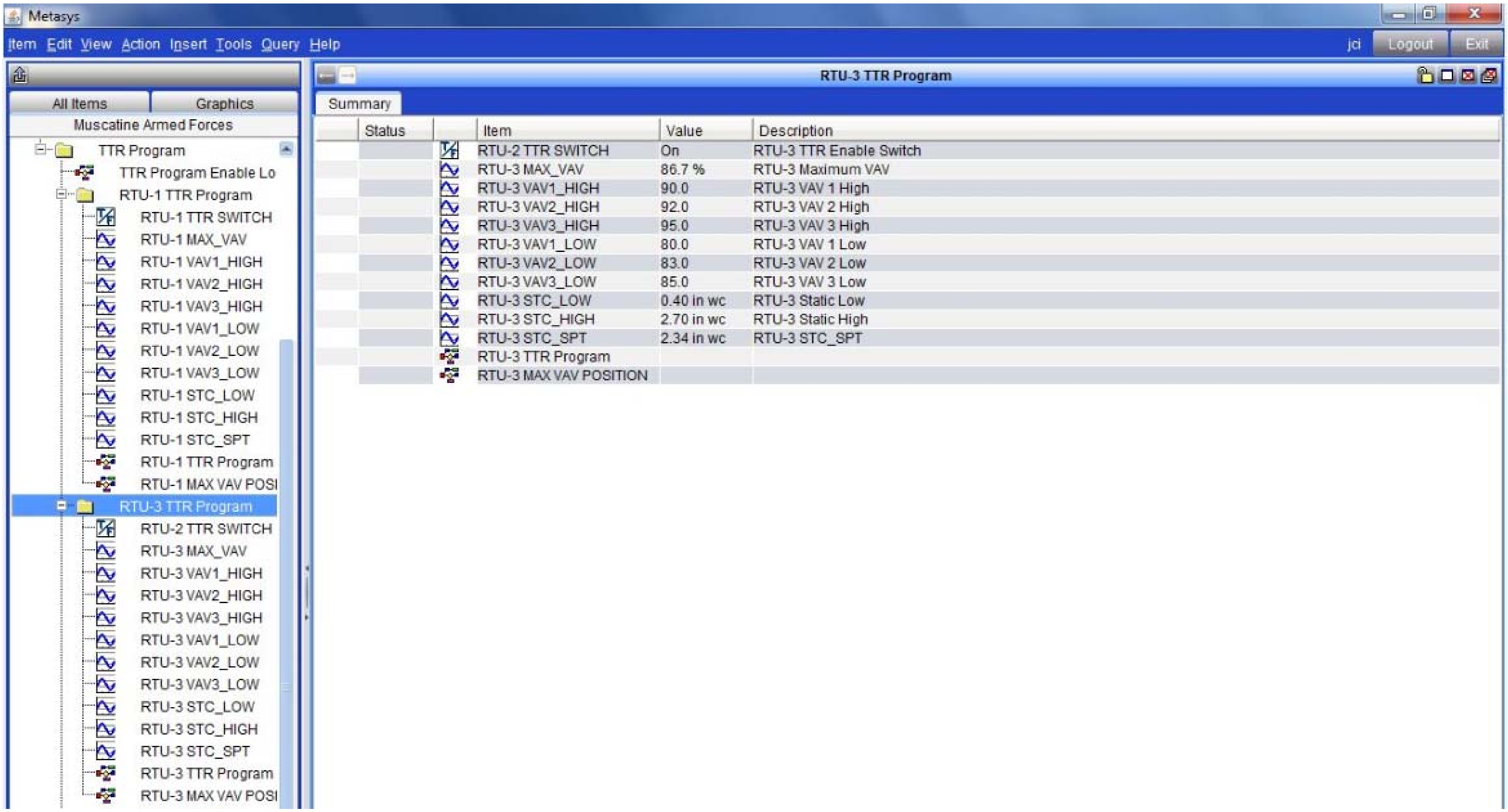
14	Override VAV damper signals as follows: VAV-A to 99% (others unchanged).	Setpoint increases by 0.54 in H2O	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**12:00:17 PM**		
			VAV-A damper position signal %	**99**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
			Setpoint after 90 seconds is 1.24 inches H2O (Y/N)	**Y**		
			Setpoint at start of next step equals	**1.24**		
15	Override VAV damper signals as follows: VAV-A to 90% (others unchanged) Wait 120 seconds (two cycles).	Setpoint remains unchanged at 1.24 inches H2O.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**12:01:43 PM**		
			VAV-A damper position signal %	**90**		
			VAV-B damper position signal %	**90**		
			VAV-C damper position signal %	**90**		
			Setpoint equals 1.24 inches H2O (Y/N)	**Y**		
			Setpoint does not vary during this step (Y/N)	**Y**		
16	"Release overrides on all VAV damper position signals.	System operates normally under automatic control. If most open damper is <87% or >92%, setpoint will change. Otherwise setpoint is unchanged.	Date: Insert Date & Time	**5/12/2015**		Yes
			Time:	**12:03:20 PM**		
			Most open damper position signal %	**100**		
			Setpoint changes (Y/N)	**Y**		
			Final setpoint value (inches H2O)	**1.6**		

APPENDIX E TTR DEMONSTRATION USER INTERFACE SAMPLES

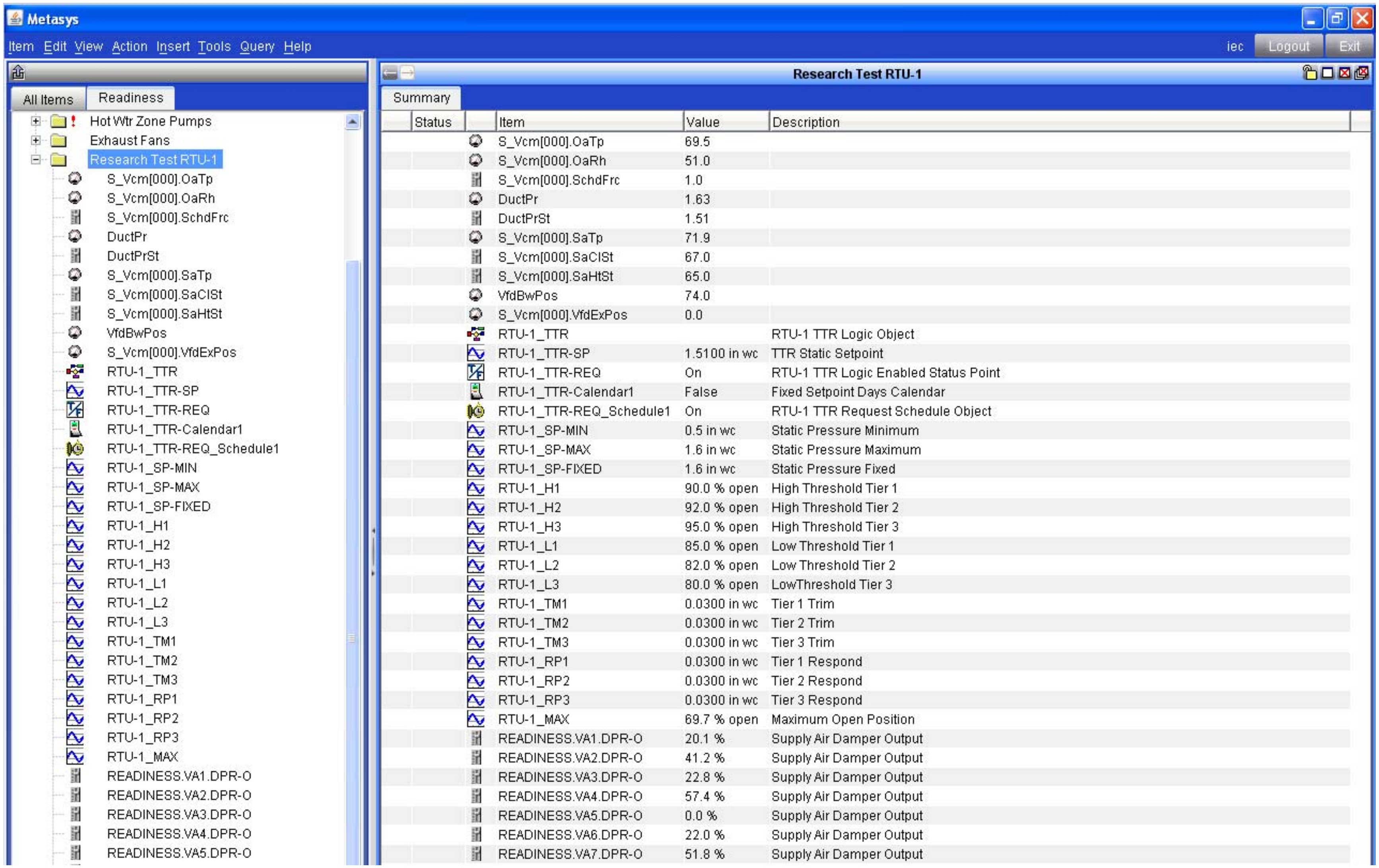
Site #1:



Site #2:

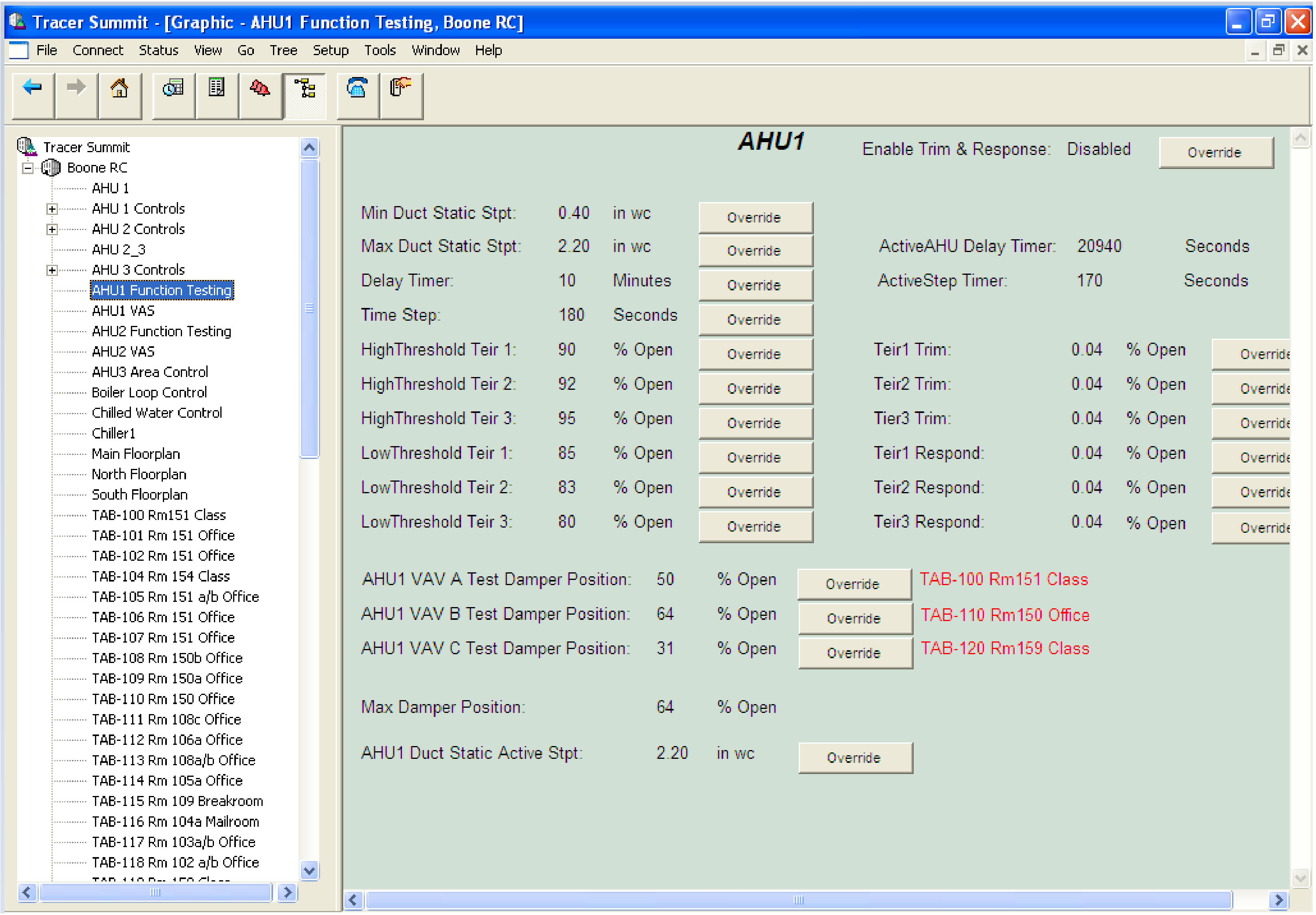

Metasys
Item Edit View Action Insert Tools Query Help
jci Logout Exit
All Items Graphics
Muscatine Armed Forces
TTR Program
TTR Program Enable Lo
RTU-1 TTR Program
RTU-1 TTR SWITCH
RTU-1 MAX_VAV
RTU-1 VAV1_HIGH
RTU-1 VAV2_HIGH
RTU-1 VAV3_HIGH
RTU-1 VAV1_LOW
RTU-1 VAV2_LOW
RTU-1 VAV3_LOW
RTU-1 STC_LOW
RTU-1 STC_HIGH
RTU-1 STC_SPT
RTU-1 TTR Program
RTU-1 MAX VAV POSI
RTU-3 TTR Program
RTU-2 TTR SWITCH
RTU-3 MAX_VAV
RTU-3 VAV1_HIGH
RTU-3 VAV2_HIGH
RTU-3 VAV3_HIGH
RTU-3 VAV1_LOW
RTU-3 VAV2_LOW
RTU-3 VAV3_LOW
RTU-3 STC_LOW
RTU-3 STC_HIGH
RTU-3 STC_SPT
RTU-3 TTR Program
RTU-3 MAX VAV POSI
RTU-3 TTR Program
Summary
Status Item Value Description
RTU-2 TTR SWITCH On RTU-3 TTR Enable Switch
RTU-3 MAX_VAV 86.7 % RTU-3 Maximum VAV
RTU-3 VAV1_HIGH 90.0 RTU-3 VAV 1 High
RTU-3 VAV2_HIGH 92.0 RTU-3 VAV 2 High
RTU-3 VAV3_HIGH 95.0 RTU-3 VAV 3 High
RTU-3 VAV1_LOW 80.0 RTU-3 VAV 1 Low
RTU-3 VAV2_LOW 83.0 RTU-3 VAV 2 Low
RTU-3 VAV3_LOW 85.0 RTU-3 VAV 3 Low
RTU-3 STC_LOW 0.40 in wc RTU-3 Static Low
RTU-3 STC_HIGH 2.70 in wc RTU-3 Static High
RTU-3 STC_SPT 2.34 in wc RTU-3 STC_SPT
RTU-3 TTR Program
RTU-3 MAX VAV POSITION

Site #3:

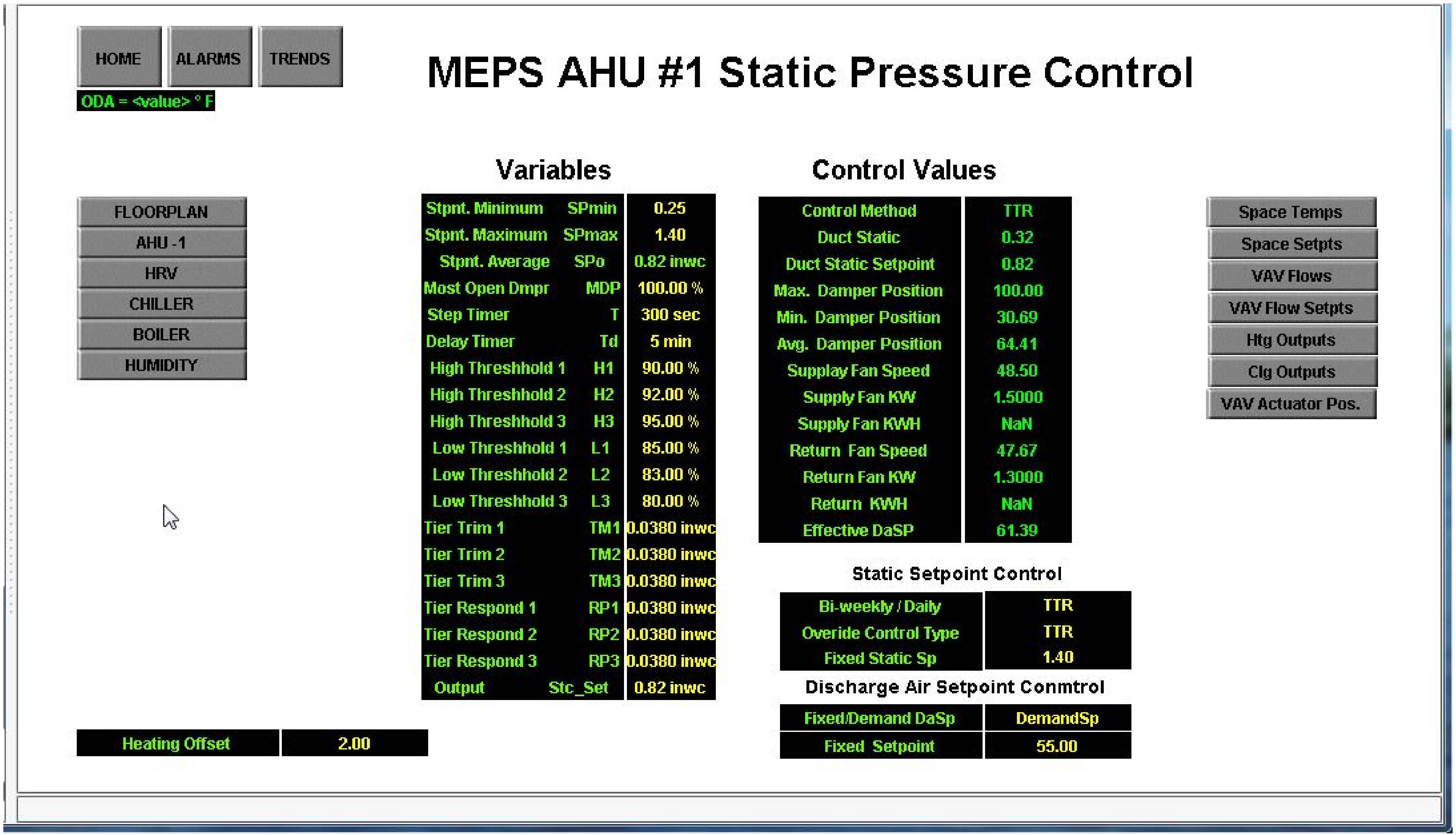


Status	Item	Value	Description
	S_Vcm[000].OaTp	69.5	
	S_Vcm[000].OaRh	51.0	
	S_Vcm[000].SchdFrc	1.0	
	DuctPr	1.63	
	DuctPrSt	1.51	
	S_Vcm[000].SaTp	71.9	
	S_Vcm[000].SaClSt	67.0	
	S_Vcm[000].SaHtSt	65.0	
	VfdBwPos	74.0	
	S_Vcm[000].VfdExPos	0.0	
	RTU-1_TTR		RTU-1 TTR Logic Object
	RTU-1_TTR-SP	1.5100 in wc	TTR Static Setpoint
	RTU-1_TTR-REQ	On	RTU-1 TTR Logic Enabled Status Point
	RTU-1_TTR-Calendar1	False	Fixed Setpoint Days Calendar
	RTU-1_TTR-REQ_Schedule1	On	RTU-1 TTR Request Schedule Object
	RTU-1_SP-MIN	0.5 in wc	Static Pressure Minimum
	RTU-1_SP-MAX	1.6 in wc	Static Pressure Maximum
	RTU-1_SP-FIXED	1.6 in wc	Static Pressure Fixed
	RTU-1_H1	90.0 % open	High Threshold Tier 1
	RTU-1_H2	92.0 % open	High Threshold Tier 2
	RTU-1_H3	95.0 % open	High Threshold Tier 3
	RTU-1_L1	85.0 % open	Low Threshold Tier 1
	RTU-1_L2	82.0 % open	Low Threshold Tier 2
	RTU-1_L3	80.0 % open	LowThreshold Tier 3
	RTU-1_TM1	0.0300 in wc	Tier 1 Trim
	RTU-1_TM2	0.0300 in wc	Tier 2 Trim
	RTU-1_TM3	0.0300 in wc	Tier 3 Trim
	RTU-1_RP1	0.0300 in wc	Tier 1 Respond
	RTU-1_RP2	0.0300 in wc	Tier 2 Respond
	RTU-1_RP3	0.0300 in wc	Tier 3 Respond
	RTU-1_MAX	69.7 % open	Maximum Open Position
	READINESS.VA1.DPR-O	20.1 %	Supply Air Damper Output
	READINESS.VA2.DPR-O	41.2 %	Supply Air Damper Output
	READINESS.VA3.DPR-O	22.8 %	Supply Air Damper Output
	READINESS.VA4.DPR-O	57.4 %	Supply Air Damper Output
	READINESS.VA5.DPR-O	0.0 %	Supply Air Damper Output
	READINESS.VA6.DPR-O	22.0 %	Supply Air Damper Output
	READINESS.VA7.DPR-O	51.8 %	Supply Air Damper Output

Site #4:


Tracer Summit - [Graphic - AHU1 Function Testing, Boone RC]
File Connect Status View Go Tree Setup Tools Window Help
Tracer Summit
Boone RC
AHU 1
AHU 1 Controls
AHU 2 Controls
AHU 2_3
AHU 3 Controls
AHU1 Function Testing
AHU1 VAS
AHU2 Function Testing
AHU2 VAS
AHU3 Area Control
Boiler Loop Control
Chilled Water Control
Chiller1
Main Floorplan
North Floorplan
South Floorplan
TAB-100 Rm151 Class
TAB-101 Rm 151 Office
TAB-102 Rm 151 Office
TAB-104 Rm 154 Class
TAB-105 Rm 151 a/b Office
TAB-106 Rm 151 Office
TAB-107 Rm 151 Office
TAB-108 Rm 150b Office
TAB-109 Rm 150a Office
TAB-110 Rm 150 Office
TAB-111 Rm 108c Office
TAB-112 Rm 106a Office
TAB-113 Rm 108a/b Office
TAB-114 Rm 105a Office
TAB-115 Rm 109 Breakroom
TAB-116 Rm 104a Mailroom
TAB-117 Rm 103a/b Office
TAB-118 Rm 102 a/b Office
AHU1
Enable Trim & Response: Disabled Override
Min Duct Static Stpt: 0.40 in wc Override
Max Duct Static Stpt: 2.20 in wc Override
ActiveAHU Delay Timer: 20940 Seconds
Delay Timer: 10 Minutes Override
ActiveStep Timer: 170 Seconds
Time Step: 180 Seconds Override
HighThreshold Teir 1: 90 % Open Override
HighThreshold Teir 2: 92 % Open Override
HighThreshold Teir 3: 95 % Open Override
LowThreshold Teir 1: 85 % Open Override
LowThreshold Teir 2: 83 % Open Override
LowThreshold Teir 3: 80 % Open Override
Teir1 Trim: 0.04 % Open Override
Teir2 Trim: 0.04 % Open Override
Tier3 Trim: 0.04 % Open Override
Teir1 Respond: 0.04 % Open Override
Teir2 Respond: 0.04 % Open Override
Teir3 Respond: 0.04 % Open Override
AHU1 VAV A Test Damper Position: 50 % Open Override TAB-100 Rm151 Class
AHU1 VAV B Test Damper Position: 64 % Open Override TAB-110 Rm150 Office
AHU1 VAV C Test Damper Position: 31 % Open Override TAB-120 Rm159 Class
Max Damper Position: 64 % Open
AHU1 Duct Static Active Stpt: 2.20 in wc Override

Site #5:



HOME
ALARMS
TRENDS
ODA = <value> ° F
MEPS AHU #1 Static Pressure Control
FLOORPLAN
AHU -1
HRV
CHILLER
BOILER
HUMIDITY
Variables
Stpnt. Minimum SPmin 0.25
Stpnt. Maximum SPmax 1.40
Stpnt. Average SPo 0.82 inwc
Most Open Dmpr MDP 100.00 %
Step Timer T 300 sec
Delay Timer Td 5 min
High Threshhold 1 H1 90.00 %
High Threshhold 2 H2 92.00 %
High Threshhold 3 H3 95.00 %
Low Threshhold 1 L1 85.00 %
Low Threshhold 2 L2 83.00 %
Low Threshhold 3 L3 80.00 %
Tier Trim 1 TM1 0.0380 inwc
Tier Trim 2 TM2 0.0380 inwc
Tier Trim 3 TM3 0.0380 inwc
Tier Respond 1 RP1 0.0380 inwc
Tier Respond 2 RP2 0.0380 inwc
Tier Respond 3 RP3 0.0380 inwc
Output Stc_Set 0.82 inwc
Control Values
Control Method TTR
Duct Static 0.32
Duct Static Setpoint 0.82
Max. Damper Position 100.00
Min. Damper Position 30.69
Avg. Damper Position 64.41
Supplay Fan Speed 48.50
Supply Fan KW 1.5000
Supply Fan KWH NaN
Return Fan Speed 47.67
Return Fan KW 1.3000
Return KWH NaN
Effective DaSP 61.39
Static Setpoint Control
Bi-weekly / Daily TTR
Overide Control Type TTR
Fixed Static Sp 1.40
Discharge Air Setpoint Conmtrol
Fixed/Demand DaSp DemandSp
Fixed Setpoint 55.00
Space Temps
Space Setpts
VAV Flows
VAV Flow Setpts
Htg Outputs
Clg Outputs
VAV Actuator Pos.
Heating Offset 2.00

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APPENDIX F DAILY FAN ENERGY USE DATA

Site #1:

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
8/9/2015	Sunday	74.95	73.208	15.966	1.469	449.729	575.545	4436.636		
8/10/2015	Monday	73.93	144.857	66.567	23.442	458.765	867.410			
8/11/2015	Tuesday	72.47	136.503	63.354	17.337	464.766	822.262			
8/12/2015	Wednesday	71.52	120.929	55.255	15.761	464.211	795.435			
8/13/2015	Thursday	74.54	120.559	53.849	16.007	464.356	791.154			
8/14/2015	Friday	77.74	120.726	55.402	16.778	464.950	778.880			
8/15/2015	Saturday	76.01	76.820	10.817	0.000	464.252	565.099			
8/16/2015	Sunday	77.03	65.639	12.210	3.250	463.483	571.227	4203.523		
8/17/2015	Monday	71.60	126.168	61.954	21.336	461.868	817.845		14899.190	5.49%
8/18/2015	Tuesday	67.19	101.327	48.870	16.534	467.524	729.536		14763.890	4.94%
8/19/2015	Wednesday	60.52	74.268	47.844	14.203	469.732	686.418		13918.140	4.93%
8/20/2015	Thursday	65.87	82.336	48.854	13.575	488.620	736.714		14000.870	5.26%
8/21/2015	Friday	71.07	85.541	50.128	13.619	459.266	712.183		14676.200	4.85%
8/22/2015	Saturday	71.22	50.371	0.000	0.000	455.002	505.711		12406.100	4.08%
9/6/2015	Sunday	81.87	118.013	82.798	34.254	419.670	726.033	4583.681	15890.340	4.57%
9/7/2015	Monday	76.74	117.879	83.291	33.736	419.719	722.512		15741.320	4.59%
9/8/2015	Tuesday	73.98	118.921	83.204	32.893	422.421	730.543		16840.420	4.34%
9/9/2015	Wednesday	69.34	123.717	84.683	29.464	425.655	755.827		16885.980	4.48%
9/10/2015	Thursday	71.52	130.058	83.817	30.204	430.356	770.950		17204.230	4.48%
9/11/2015	Friday	59.66	123.186	82.550	27.568	452.130	771.200			
9/12/2015	Saturday	56.46	67.518	43.544	14.264	468.167	642.919			
9/13/2015	Sunday	59.99	69.043	44.737	14.582	463.471	649.182	4657.698		
9/14/2015	Monday	70.26	126.324	82.630	27.147	440.647	772.305			

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
9/15/2015	Tuesday	74.34	122.970	82.210	27.208	441.436	753.335			
9/16/2015	Wednesday	75.30	127.829	84.100	28.874	440.908	779.895			
9/17/2015	Thursday	76.49	118.052	83.477	30.024	439.682	747.392			
9/18/2015	Friday	62.70	116.691	83.063	28.139	443.574	738.580			
9/19/2015	Saturday	57.43	112.635	84.190	24.308	469.744	747.132			
10/4/2015	Sunday	48.28	108.393	66.894	23.846	473.628	724.230	4572.716	14174.620	5.11%
10/5/2015	Monday	55.63	109.308	65.681	24.298	458.982	726.318		14119.560	5.14%
10/6/2015	Tuesday	59.89	109.378	64.634	24.817	451.931	712.998		14356.760	4.97%
10/7/2015	Wednesday	63.89	114.173	62.802	24.968	448.348	719.052		12567.940	5.72%
10/8/2015	Thursday	67.24	121.432	62.384	27.309	447.500	741.711		12411.760	5.98%
10/9/2015	Friday	54.49	103.290	62.194	26.245	459.333	712.633		12567.940	5.67%
10/10/2015	Saturday	55.35	98.082	62.341	24.211	446.312	695.602		12411.760	5.60%
10/11/2015	Sunday	68.46	98.306	62.673	23.927	424.444	664.382	4354.656	13780.810	4.82%
10/12/2015	Monday	65.21	100.527	62.545	24.688	425.097	660.183		13651.820	4.84%
10/13/2015	Tuesday	53.85	108.662	62.375	24.592	451.344	722.935		12813.700	5.64%
10/14/2015	Wednesday	52.36	111.397	62.491	24.125	472.832	751.428		12968.410	5.79%
10/15/2015	Thursday	55.27	87.338	46.700	18.108	473.954	687.290		13105.390	5.24%
10/16/2015	Friday	45.44	66.662	35.548	13.396	482.158	661.400		12124.590	5.46%
10/17/2015	Saturday	43.32	67.775	42.111	16.182	464.700	630.535		12074.610	5.22%
11/1/2015	Sunday	57.15	0.000	0.000	0.000	478.966	479.393	4044.692		
11/2/2015	Monday	62.60	0.000	34.932	13.140	460.704	565.814		12452.550	4.54%
11/3/2015	Tuesday	58.44	47.029	35.448	14.524	385.114	546.981		12968.080	
11/4/2015	Wednesday	59.28	91.149	35.296	14.987	275.241	478.692		13977.460	
11/5/2015	Thursday	59.10	81.943	35.301	14.926	279.626	466.442		13914.400	
11/6/2015	Friday	45.66	79.676	35.935	13.838	297.050	489.122		12267.840	
11/7/2015	Saturday	40.44	67.798	33.676	12.164	297.422	457.700		11911.240	
11/8/2015	Sunday	44.12	65.936	33.820	11.900	294.562	450.828		12190.620	
11/9/2015	Monday	43.46	72.816	35.931	13.171	296.880	462.171		12606.080	

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
11/10/2015	Tuesday	47.16	78.176	35.657	13.434	293.220	466.340		12900.150	
11/11/2015	Wednesday	52.08	74.839	35.656	13.380	296.246	457.937		11855.260	
11/12/2015	Thursday	44.09	76.924	36.260	13.388	296.607	476.916		12389.200	
11/13/2015	Friday	39.45	72.801	36.422	13.424	300.603	460.075		12700.190	
11/14/2015	Saturday	48.99	0.000	0.000	0.000	290.131	290.535		11838.580	
11/29/2015	Sunday	32.41	0.000	0.000	0.000	272.764	273.166		11423.913	
11/30/2015	Monday	34.66	79.157	38.579	13.162	279.630	473.326		12711.606	
12/1/2015	Tuesday	32.66	85.579	41.233	13.389	280.075	495.583		12742.310	
12/2/2015	Wednesday	33.95	85.978	40.724	13.414	265.848	478.677		12666.950	
12/3/2015	Thursday	33.52	94.643	42.944	13.433	265.198	500.951		12842.540	
12/4/2015	Friday	36.59	82.313	41.162	13.418	264.009	482.496		12380.410	
12/5/2015	Saturday	39.63	0.000	0.000	0.000	264.566	264.875		11546.790	
12/6/2015	Sunday	39.00	0.000	0.000	0.000	264.955	265.272		11437.030	
12/7/2015	Monday	38.14	94.449	38.667	13.164	266.429	489.410		12451.880	
12/8/2015	Tuesday	40.07	85.659	39.858	13.420	274.019	490.220		12379.070	
12/9/2015	Wednesday	44.50	94.397	42.695	13.403	293.830	532.754		12382.930	
12/10/2015	Thursday	50.89	83.581	40.547	13.644	308.876	523.522		12335.730	
12/11/2015	Friday	43.23	79.995	39.421	13.994	299.593	506.479		12467.580	
12/12/2015	Saturday	42.55	0.000	0.000	0.000	292.048	292.377		10967.600	
12/27/2015	Sunday	25.13	0.000	0.000	0.000	276.549	276.884		12010.230	
12/28/2015	Monday	25.13	95.632	39.455	13.108	285.641	508.111		13424.330	
12/29/2015	Tuesday	23.68	106.283	40.047	13.403	284.953	523.247		13742.170	
12/30/2015	Wednesday	25.26	103.134	40.282	13.409	282.047	514.638		13599.520	
12/31/2015	Thursday	21.17	100.996	44.529	13.365	279.117	511.330		13324.530	
1/1/2016	Friday	26.68	95.515	40.749	13.403	264.429	485.466		12879.720	
1/2/2016	Saturday	23.99	0.000	0.000	0.000	266.505	266.852		12350.420	
1/3/2016	Sunday	23.81	0.000	0.000	0.000	273.518	273.858		12273.540	
1/4/2016	Monday	24.32	103.297	41.023	13.114	282.459	522.140		13650.090	

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
1/5/2016	Tuesday	26.08	113.157	46.153	13.413	274.123	523.245		13298.930	
1/6/2016	Wednesday	31.06	73.612	46.338	13.420	292.174	517.091		13559.350	
1/7/2016	Thursday	34.36	76.358	42.001	13.391	301.505	522.042		13369.430	
1/8/2016	Friday	33.17	105.232	41.454	13.400	303.198	556.279		13271.480	
1/9/2016	Saturday	10.45	32.475	22.849	8.714	284.221	358.585		13167.910	
1/24/2016	Sunday	28.78	0.000	0.000	0.000	450.492	450.864	4001.010	12090.570	3.73%
1/25/2016	Monday	27.31	114.702	39.711	13.144	463.290	711.578		13346.930	5.33%
1/26/2016	Tuesday	28.37	112.294	43.133	13.416	461.123	703.880		13392.830	5.26%
1/27/2016	Wednesday	32.05	122.222	42.584	13.389	447.081	695.785		13323.670	5.22%
1/28/2016	Thursday	33.57	105.917	43.183	13.392	447.489	698.443		13147.130	5.31%
1/29/2016	Friday	33.44	106.169	45.997	13.419	443.429	693.600		12742.590	5.44%
1/30/2016	Saturday	39.02	0.000	0.000	0.000	445.434	445.798		11068.170	4.03%
1/31/2016	Sunday	37.37	0.000	0.000	0.000	446.422	446.765	3825.694	11130.540	4.01%
2/1/2016	Monday	34.61	127.303	40.830	13.158	439.313	720.003		12650.640	5.69%
2/2/2016	Tuesday	33.70	64.531	40.285	13.340	450.438	655.922		12957.610	5.06%
2/3/2016	Wednesday	22.67	64.802	41.739	13.390	455.768	671.893		13360.050	5.03%
2/4/2016	Thursday	22.54	67.080	46.231	13.305	455.727	672.126		13517.570	4.97%
2/5/2016	Friday	22.47	66.984	45.686	13.334	451.060	627.173		13464.740	4.66%
2/6/2016	Saturday	32.91	0.000	0.000	0.000	454.966	455.277		12746.840	3.57%
2/21/2016	Sunday	36.03	0.000	0.000	0.000	476.170	476.496	3939.839	11371.910	4.19%
2/22/2016	Monday	36.04	95.451	44.717	13.168	477.695	765.400		12694.220	6.03%
2/23/2016	Tuesday	37.15	88.512	41.165	13.347	463.996	719.540		12843.020	5.60%
2/24/2016	Wednesday	34.84	95.918	44.774	13.395	452.777	729.731		12899.730	5.66%
2/25/2016	Thursday	31.04	97.439	45.055	13.401	443.897	725.777		13073.370	5.55%
2/26/2016	Friday	36.44	90.972	40.575	13.426	443.544	717.813		12894.290	5.57%
2/27/2016	Saturday	49.90	0.000	0.000	0.000	430.445	430.789		11002.110	3.92%
2/28/2016	Sunday	48.45	0.000	0.000	0.000	454.003	454.321	3940.505	10850.050	4.19%
2/29/2016	Monday	38.62	87.731	39.305	13.160	459.944	711.416		12518.360	5.68%

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
3/1/2016	Tuesday	23.05	100.029	38.873	13.397	445.665	655.621		13493.010	4.86%
3/2/2016	Wednesday	25.52	81.615	39.173	13.352	466.008	717.913		13631.510	5.27%
3/3/2016	Thursday	31.49	66.709	42.247	13.430	470.051	683.186		13374.080	5.11%
3/4/2016	Friday	37.50	84.564	41.341	13.415	477.179	741.746		12810.710	5.79%
3/5/2016	Saturday	35.39	0.000	0.000	0.000	479.316	479.648		12058.590	3.98%
3/20/2016	Sunday	37.32	0.000	0.000	0.000	466.945	467.320	4070.022	11357.220	4.11%
3/21/2016	Monday	43.10	86.525	46.226	13.149	484.423	731.054		12761.770	5.73%
3/22/2016	Tuesday	54.69	84.041	42.979	13.333	484.257	698.997		13002.190	5.38%
3/23/2016	Wednesday	43.74	108.313	44.117	13.424	498.800	772.797		12143.590	6.36%
3/24/2016	Thursday	33.50	65.316	44.378	13.397	481.616	710.229		12588.080	5.64%
3/25/2016	Friday	39.66	87.470	53.788	13.398	470.817	759.183		12742.840	5.96%
3/26/2016	Saturday	44.78	0.000	0.000	0.000	453.310	453.682		10993.490	4.13%
3/27/2016	Sunday	40.06	0.000	0.000	0.000	448.855	449.224	4163.581	11023.440	4.08%
3/28/2016	Monday	49.77	83.482	50.945	13.153	452.226	640.475		12562.900	5.10%
3/29/2016	Tuesday	52.48	103.275	51.351	13.421	465.248	682.985		13322.520	5.13%
3/30/2016	Wednesday	58.80	91.939	45.371	13.313	488.614	680.944		13508.770	5.04%
3/31/2016	Thursday	47.92	111.365	49.062	13.427	520.927	744.843		12196.040	6.11%
4/1/2016	Friday	40.97	0.000	47.132	13.418	496.672	608.641		12145.760	5.01%
4/2/2016	Saturday	39.88	0.000	0.000	0.000	492.871	493.171		11742.540	4.20%
4/17/2016	Sunday	67.52	0.000	0.000	0.000	425.031	425.346	3889.510	12091.350	3.52%
4/18/2016	Monday	65.72	92.879	43.576	13.158	415.370	627.658		14678.790	4.28%
4/19/2016	Tuesday	54.51	85.593	44.387	13.418	466.131	662.854		12628.090	5.25%
4/20/2016	Wednesday	55.15	84.700	39.894	13.408	483.047	670.636		12267.340	5.47%
4/21/2016	Thursday	55.35	78.494	40.324	13.412	476.825	646.734		12766.840	5.07%
4/22/2016	Friday	54.06	72.316	38.894	13.442	481.109	640.596		11857.050	5.40%
4/23/2016	Saturday	57.35	0.000	0.000	0.000	454.103	454.411		11501.400	3.95%
4/24/2016	Sunday	67.75	0.000	0.000	0.000	442.662	442.985	4036.885	11872.380	3.73%
4/25/2016	Monday	65.01	87.051	42.242	13.328	459.004	661.014		13847.280	4.77%

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
4/26/2016	Tuesday	57.81	78.192	39.930	13.513	481.660	658.180		13141.660	5.01%
4/27/2016	Wednesday	48.20	82.189	39.682	13.437	505.710	689.558		12238.000	5.63%
4/28/2016	Thursday	49.80	81.236	40.196	13.423	501.548	668.469		12269.060	5.45%
4/29/2016	Friday	47.46	79.566	40.349	13.419	485.695	643.259		12229.370	5.26%
4/30/2016	Saturday	46.48	0.000	0.000	0.000	482.852	483.216		11054.720	4.37%
5/15/2016	Sunday	52.84	0.000	0.000	0.000	466.583	466.900	4517.910	12016.510	3.89%
5/16/2016	Monday	54.54	109.466	57.801	19.226	481.799	730.247		13153.570	5.55%
5/17/2016	Tuesday	52.81	121.143	67.916	24.294	469.648	726.817		13736.570	5.29%
5/18/2016	Wednesday	55.05	117.858	73.218	24.295	461.935	825.476		12985.520	6.36%
5/19/2016	Thursday	58.72	124.139	74.037	24.275	459.432	847.781		13364.770	6.34%
5/20/2016	Friday	60.62	121.446	69.726	24.249	467.356	841.284		13358.230	6.30%
5/21/2016	Saturday	61.21	113.346	65.967	24.283	454.472	782.622		13243.220	5.91%
5/22/2016	Sunday	65.39	110.027	65.520	24.284	271.065	578.281	4420.935	12612.930	4.58%
5/23/2016	Monday	68.30	116.112	64.631	24.275	299.431	617.150		14844.170	4.16%
5/24/2016	Tuesday	70.94	119.238	64.423	24.264	434.967	752.267		16365.820	4.60%
5/25/2016	Wednesday	70.99	113.294	64.735	24.263	432.103	744.624		16724.360	4.45%
5/26/2016	Thursday	68.94	112.928	67.545	24.252	434.681	757.442		16010.070	4.73%
5/27/2016	Friday	67.14	113.728	68.154	24.263	428.746	778.011		16142.610	4.82%
5/28/2016	Saturday	67.06	100.181	64.962	24.334	421.201	681.419		13894.700	4.90%
6/12/2016	Sunday	84.67	46.846	32.629	10.478	263.249	400.599		13858.060	2.89%
6/13/2016	Monday	82.23	112.795	85.834	17.427	262.910	743.252		16109.940	4.61%
6/14/2016	Tuesday	78.25	101.309	54.238	16.800	263.976	666.055		16084.150	4.14%
6/15/2016	Wednesday	83.45	97.779	48.137	15.713	261.850	627.188		15645.480	4.01%
6/16/2016	Thursday	79.83	101.634	46.337	15.976	261.506	617.211		15609.740	3.95%
6/17/2016	Friday	78.98	99.678	42.681	15.987	261.500	596.543		15348.180	3.89%
6/18/2016	Saturday	80.79	0.000	0.000	0.000	261.661	262.004		12784.020	2.05%
6/19/2016	Sunday	80.72	0.000	0.000	0.000	0.000	0.000		14090.770	
6/20/2016	Monday	80.31	0.000	0.000	0.000	0.000	0.000		15584.260	

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
6/21/2016	Tuesday	78.50	0.000	0.000	0.000	0.000	0.000		15677.720	
6/22/2016	Wednesday	82.00	0.000	0.000	0.000	0.000	0.000		16145.350	
6/23/2016	Thursday	76.51	0.000	0.000	0.000	0.000	0.000		15897.310	
6/24/2016	Friday	76.28	0.000	0.000	0.000	0.000	0.000		15072.650	
6/25/2016	Saturday	84.08	0.000	0.000	0.000	0.000	0.000		13240.670	
7/10/2016	Sunday	76.33	68.764	34.389	22.354	258.368	485.013	4069.990	430.280	
7/11/2016	Monday	84.70	96.923	43.854	21.048	257.012	581.074		1563.690	
7/12/2016	Tuesday	75.90	90.686	41.177	20.743	258.125	557.202		1347.990	
7/13/2016	Wednesday	76.56	90.295	40.955	21.123	231.488	519.493			
7/14/2016	Thursday	78.18	91.397	40.149	20.056	431.136	727.687			
7/15/2016	Friday	69.73	94.933	43.305	19.797	446.186	772.515			
7/16/2016	Saturday	74.30	68.075	37.190	17.894	425.790	653.028			
7/17/2016	Sunday	76.71	60.312	33.170	19.586	420.130	599.838	3828.310		
7/18/2016	Monday	77.81	78.766	38.025	19.193	422.083	687.892			
7/19/2016	Tuesday	72.79	68.959	36.348	19.815	422.791	646.480			
7/20/2016	Wednesday	82.94	81.599	38.859	18.630	427.890	711.397			
7/21/2016	Thursday	87.62	95.385	46.348	21.377	437.353	779.927			
7/22/2016	Friday	84.07	78.089	43.546	23.049	435.706	741.337			
7/23/2016	Saturday	85.23	2.319	1.489	0.380	437.112	443.044			
8/7/2016	Sunday	73.31	0.000	32.298	20.767	435.199	544.125			
8/8/2016	Monday	74.07	0.000	37.323	22.830	465.663	644.460			
8/9/2016	Tuesday	79.42	0.000	41.469	22.088	436.313	648.934			
8/10/2016	Wednesday	81.27	0.000	41.578	22.050	434.852	660.552			
8/11/2016	Thursday	78.79	0.000	38.144	21.882	433.360	632.600			
8/12/2016	Friday	75.88	0.000	37.828	21.868	432.691	629.914			
8/13/2016	Saturday	76.22	0.000	33.059	18.625	432.119	629.349			
8/14/2016	Sunday	76.91	0.000	26.806	15.769	428.500	598.534			
8/15/2016	Monday	75.76	0.000	39.947	23.959	426.687	664.433			

Fixed Static Pressure										
Date		Average Daily Temp.	AHU-1	AHU-4	AHU-9	AHU-12	All AHUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
8/16/2016	Tuesday	76.89	0.000	39.481	23.437	418.333	653.156			
8/17/2016	Wednesday	78.95	0.000	42.402	23.256	437.436	678.630			
8/18/2016	Thursday	81.94	0.000	43.808	23.370	435.787	685.284			
8/19/2016	Friday	77.10	0.000	42.590	23.820	434.810	673.320			
8/20/2016	Saturday	68.89	0.000	38.125	24.182	428.189	615.772			
9/4/2016	Sunday	71.12	0.000	31.778	18.674	419.209	505.040		14110.850	3.58%
9/5/2016	Monday	78.69	0.000	32.325	18.750	418.898	529.196		14457.890	3.66%
9/6/2016	Tuesday	83.51	0.000	38.598	21.061	420.811	585.429		15725.204	3.72%
9/7/2016	Wednesday	77.08	0.000	35.348	22.072	423.253	575.333		15412.057	3.73%
9/8/2016	Thursday	76.61	0.000	36.124	21.037	423.976	584.573		15372.075	3.80%
9/9/2016	Friday	72.64	0.000	34.311	22.762	424.123	571.479		15201.935	3.76%
9/10/2016	Saturday	65.32	0.000	36.938	24.150	459.985	606.614		13288.781	4.56%
9/11/2016	Sunday	66.07	0.000	34.534	22.118	450.021	593.420		13215.656	4.49%
9/12/2016	Monday	71.71	0.000	35.729	24.517	452.828	599.019		14062.539	4.26%
9/13/2016	Tuesday	67.87	0.000	33.729	23.225	431.451	569.031		15002.006	3.79%
9/14/2016	Wednesday	66.58	0.000	33.457	18.226	446.172	566.170		14500.036	3.90%
9/15/2016	Thursday	70.57	0.000	33.566	21.228	426.581	556.802		15299.516	3.64%
9/16/2016	Friday	66.69	0.000	35.097	19.950	424.935	557.252		15049.563	3.70%
9/17/2016	Saturday	68.32	0.000	36.304	18.882	430.756	570.690		13396.398	4.26%

Site #1:

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
7/26/2015	Sunday	77.51	38.954	15.108	3.345	284.542	385.753	2926.025		
7/27/2015	Monday	74.11	106.351	64.918	14.306	288.236	667.359			
7/28/2015	Tuesday	74.39	85.116	37.056	9.163	290.803	560.469			
7/29/2015	Wednesday	75.99	78.920	44.932	7.812	288.617	567.195			
7/30/2015	Thursday	75.45	104.314	54.082	9.604	292.138	614.544			
7/31/2015	Friday	74.97	80.689	51.421	8.060	291.886	581.416			
8/1/2015	Saturday	75.30	35.390	11.482	0.000	286.569	351.714			
8/2/2015	Sunday	80.50	40.661	18.952	1.494	286.779	397.618	3008.708		
8/3/2015	Monday	71.80	143.792	79.455	13.538	302.675	768.832			
8/4/2015	Tuesday	69.50	72.028	42.121	8.522	335.905	586.935			
8/5/2015	Wednesday	71.14	77.950	28.748	8.277	311.848	537.683			
8/6/2015	Thursday	72.28	80.289	40.137	8.039	310.988	579.112			
8/7/2015	Friday	76.56	80.145	42.050	7.942	318.999	588.353			
8/8/2015	Saturday	74.46	23.530	0.000	0.000	305.448	331.123			
8/23/2015	Sunday	63.71	23.958	1.491	0.000	314.671	356.351	3464.104	11599.270	3.07%
8/24/2015	Monday	62.55	136.243	66.266	7.965	355.371	769.480		13478.570	5.71%
8/25/2015	Tuesday	62.88	99.124	55.003	9.673	399.794	746.098		13583.350	5.49%
8/26/2015	Wednesday	61.66	84.212	43.518	12.137	370.025	671.350		13580.140	4.94%
8/27/2015	Thursday	63.18	70.465	28.146	11.491	335.480	569.913		13833.370	4.12%
8/28/2015	Friday	67.21	80.589	24.034	12.106	275.025	490.495		14476.280	3.39%
8/29/2015	Saturday	67.26	44.738	18.120	8.183	268.966	402.267		13114.220	3.07%
8/30/2015	Sunday	65.82	68.752	33.836	12.352	270.945	484.321	3335.860	13962.140	3.47%
8/31/2015	Monday	74.15	105.113	51.602	14.581	270.306	592.913		16188.160	3.66%
9/1/2015	Tuesday	77.43	115.980	53.257	16.339	270.679	604.179		16480.440	3.67%
9/2/2015	Wednesday	78.17	128.628	48.449	17.505	277.748	622.102		16342.140	3.81%
9/3/2015	Thursday	79.71	106.169	43.145	19.306	283.456	580.214		16430.520	3.53%
9/4/2015	Friday	79.56	114.143	57.351	12.532	278.243	611.729		16043.930	3.81%

TTR										
Date		Average Daily Temp.	AHU-1 Total	AHU-4 Total	AHU-9 Total	AHU-12 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	kWh	%
9/5/2015	Saturday	80.47	106.434	38.816	21.760	276.082	548.741		15515.310	3.54%
9/20/2015	Sunday	59.15	96.180	93.887	6.144	287.029	563.918	3232.966		
9/21/2015	Monday	64.88	103.006	69.042	7.644	282.809	555.928			
9/22/2015	Tuesday	71.65	102.045	71.651	11.406	295.374	582.118			
9/23/2015	Wednesday	69.85	95.976	67.683	13.187	294.182	565.512			
9/24/2015	Thursday	69.60	95.640	63.806	12.343	298.600	583.071			
9/25/2015	Friday	68.52	95.352	69.591	10.173	288.619	575.761			
9/26/2015	Saturday	66.39	104.745	63.838	9.539	276.040	566.438			
9/27/2015	Sunday	66.10	69.542	35.852	6.741	359.993	559.297	3612.497		
9/28/2015	Monday	69.95	154.073	132.241	20.617	410.028	947.048			
9/29/2015	Tuesday	62.13	104.239	92.857	18.991	294.819	665.387			
9/30/2015	Wednesday	52.11	108.503	77.419	13.879	321.236	664.985			
10/1/2015	Thursday	51.54	114.509	69.512	8.645	318.231	652.835			
10/2/2015	Friday	51.24	112.028	45.526	7.853	322.690	612.797			
10/3/2015	Saturday	50.85	103.817	43.775	5.904	361.716	622.665			
10/18/2015	Sunday	46.31	51.025	14.637	3.094	288.569	426.322	2964.766	11934.880	3.57%
10/19/2015	Monday	66.10	60.448	14.313	3.362	344.710	490.059		12905.850	3.80%
10/20/2015	Tuesday	62.32	59.097	15.258	4.825	325.535	495.488		13170.000	3.76%
10/21/2015	Wednesday	59.99	69.982	17.000	9.095	287.448	471.908		12825.170	3.68%
10/22/2015	Thursday	56.17	61.644	18.173	10.615	342.942	518.593		12213.550	4.25%
10/23/2015	Friday	58.72	56.794	20.072	8.641	430.980	595.316		11933.600	4.99%
10/24/2015	Saturday	53.99	0.000	0.000	0.000	335.374	335.767		10286.710	3.26%
10/25/2015	Sunday	47.63	0.000	0.000	0.000	344.890	345.297	2930.549	10187.020	3.39%
10/26/2015	Monday	49.19	52.950	24.202	7.278	362.111	537.504		11765.100	4.57%
10/27/2015	Tuesday	47.46	59.902	19.257	4.578	308.899	478.608		11518.850	4.15%
10/28/2015	Wednesday	44.95	77.838	19.555	5.420	355.833	547.391		11734.830	4.66%
10/29/2015	Thursday	41.96	59.192	23.981	3.412	374.724	537.937		11980.300	4.49%
10/30/2015	Friday	43.61	26.743	22.741	3.425	376.959	508.749		11588.900	4.39%

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
10/31/2015	Saturday	48.53	0.000	0.000	0.000	292.647	293.045			
11/15/2015	Sunday	52.81	0.000	0.000	0.000	237.272	237.678		11138.520	
11/16/2015	Monday	51.67	34.099	20.839	3.359	255.553	388.539		11910.100	
11/17/2015	Tuesday	56.90	14.197	20.316	3.424	261.420	378.749		12183.110	
11/18/2015	Wednesday	47.03	45.608	21.296	3.432	230.205	396.271		12167.830	
11/19/2015	Thursday	38.39	59.102	23.207	3.663	234.502	417.164		13299.250	
11/20/2015	Friday	32.62	80.284	25.530	3.409	230.867	424.386		13556.860	
11/21/2015	Saturday	21.92	0.000	0.000	0.000	220.209	220.625		12373.810	
11/22/2015	Sunday	28.60	0.000	0.000	0.000	225.823	226.233		12459.540	
11/23/2015	Monday	35.19	95.574	46.355	3.338	227.039	481.454		13753.690	
11/24/2015	Tuesday	37.43	82.425	37.796	3.419	228.566	456.210		12832.390	
11/25/2015	Wednesday	51.55	69.503	18.094	3.506	238.632	426.451		11757.560	
11/26/2015	Thursday	38.25	69.124	22.190	8.612	199.005	380.576		11241.000	
11/27/2015	Friday	28.68	75.260	24.510	3.678	209.171	391.380		11797.850	
11/28/2015	Saturday	27.61	0.000	0.000	0.000	213.814	214.221		11447.860	
12/13/2015	Sunday	47.72	0.000	0.000	0.000	178.465	178.797		10506.540	
12/14/2015	Monday	39.07	99.370	26.150	14.693	211.972	453.143		12079.190	
12/15/2015	Tuesday	36.94	97.631	30.834	9.317	231.540	470.542		12248.340	
12/16/2015	Wednesday	35.68	95.582	27.623	7.261	196.727	428.356		12207.300	
12/17/2015	Thursday	30.71	86.669	33.262	3.417	167.332	389.676		12385.680	
12/18/2015	Friday	25.06	98.140	48.384	3.432	193.030	457.823		12962.160	
12/19/2015	Saturday	25.23	0.000	0.000	0.000	215.690	216.019		11743.860	
12/20/2015	Sunday	45.01	0.000	0.000	0.000	189.841	190.161		10723.920	
12/21/2015	Monday	34.26	88.108	35.630	4.632	239.098	460.245		12092.340	
12/22/2015	Tuesday	33.70	87.676	34.026	3.402	254.194	476.332		12360.820	
12/23/2015	Wednesday	39.55	97.098	37.609	3.426	270.105	510.057		12060.310	
12/24/2015	Thursday	29.77	75.440	26.565	3.404	238.949	435.317		11985.300	
12/25/2015	Friday	27.44	91.675	26.026	3.419	224.644	431.247		11986.520	

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
12/26/2015	Saturday	33.90	0.000	0.000	0.000	236.653	236.927		11073.980	
1/10/2016	Sunday	1.40	89.747	23.336	6.079	274.146	424.998	3259.804	13697.880	
1/11/2016	Monday	19.02	136.594	31.465	4.428	272.057	561.334		14161.010	
1/12/2016	Tuesday	5.38	149.163	38.062	5.500	300.655	610.961		14731.480	
1/13/2016	Wednesday	25.81	121.327	36.029	3.897	377.064	654.458		14396.130	
1/14/2016	Thursday	38.94	108.110	44.316	3.422	395.003	667.061		14020.750	4.76%
1/15/2016	Friday	22.19	90.481	36.748	3.413	370.696	589.358		13763.220	4.28%
1/16/2016	Saturday	10.12	35.234	11.058	2.748	370.805	439.531		12450.940	3.53%
1/17/2016	Sunday	-2.58	70.423	21.558	5.904	380.969	511.019	3818.174	12801.770	3.99%
1/18/2016	Monday	4.32	119.961	42.504	6.028	390.242	647.985		13315.520	4.87%
1/19/2016	Tuesday	10.15	118.865	33.309	4.432	404.938	652.606		13982.480	4.67%
1/20/2016	Wednesday	15.47	99.341	34.458	3.413	431.251	661.106		13789.260	4.79%
1/21/2016	Thursday	18.36	108.498	41.728	3.404	453.609	705.762		13745.740	5.13%
1/22/2016	Friday	22.14	96.669	27.147	3.413	453.088	661.738		13560.690	4.88%
1/23/2016	Saturday	21.78	0.000	0.000	0.000	448.954	449.321		12285.830	3.66%
2/7/2016	Sunday	37.10	0.000	0.000	0.000	431.710	432.010	3642.862	12621.240	3.42%
2/8/2016	Monday	18.84	60.487	44.722	3.358	427.024	584.260		13584.620	4.30%
2/9/2016	Tuesday	13.87	83.599	49.623	3.422	421.398	605.070		13820.970	4.38%
2/10/2016	Wednesday	15.52	80.435	52.036	3.413	419.513	603.615		13731.480	4.40%
2/11/2016	Thursday	12.86	110.314	62.860	3.848	410.143	640.306		13877.400	4.61%
2/12/2016	Friday	15.37	108.354	51.301	4.647	409.087	622.369		13555.020	4.59%
2/13/2016	Saturday	8.63	36.488	8.906	2.554	406.784	462.074		12638.850	3.66%
2/14/2016	Sunday	19.30	0.000	0.000	0.000	418.825	419.166	3752.657	12457.270	3.36%
2/15/2016	Monday	28.61	80.350	24.873	3.364	418.621	569.739		12818.350	4.44%
2/16/2016	Tuesday	34.08	90.024	46.569	3.420	440.537	627.614		13207.620	4.75%
2/17/2016	Wednesday	32.13	93.551	38.388	3.404	469.717	651.728		13331.900	4.89%
2/18/2016	Thursday	39.58	87.494	33.184	3.439	447.310	616.887		12915.490	4.78%
2/19/2016	Friday	51.14	82.613	36.936	2.719	421.362	587.650		11917.750	4.93%

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
2/20/2016	Saturday	44.40	0.000	0.000	0.000	484.971	485.285		11225.790	4.32%
3/6/2016	Sunday	50.76	0.000	0.000	0.000	442.484	442.743	4102.149	11580.430	3.82%
3/7/2016	Monday	61.92	79.805	59.608	3.361	457.644	735.775		11834.910	6.22%
3/8/2016	Tuesday	63.92	108.857	80.580	4.760	497.207	876.915		12211.820	7.18%
3/9/2016	Wednesday	45.16	88.227	53.256	4.706	525.207	859.872		12383.180	6.94%
3/10/2016	Thursday	44.26	102.954	44.945	3.718	510.153	828.579		12363.590	6.70%
3/11/2016	Friday	50.46	74.561	26.705	3.414	478.320	706.115		12464.780	5.66%
3/12/2016	Saturday	47.72	0.000	0.000	0.000	485.284	485.550		10481.110	4.63%
3/13/2016	Sunday	50.96	0.000	0.000	0.000	464.751	465.066	3968.095	9935.420	4.68%
3/14/2016	Monday	57.83	76.070	30.940	3.368	468.718	701.501		12542.910	5.59%
3/15/2016	Tuesday	55.32	81.700	35.545	3.518	496.312	750.637		12376.900	6.06%
3/16/2016	Wednesday	48.73	76.156	47.621	3.620	451.153	718.850		12536.370	5.73%
3/17/2016	Thursday	45.64	85.893	45.652	3.398	485.188	777.738		12571.230	6.19%
3/18/2016	Friday	36.59	75.583	38.361	3.587	478.605	750.244		12524.670	5.99%
3/19/2016	Saturday	34.61	0.000	0.000	0.000	466.613	466.985		11400.200	4.10%
4/3/2016	Sunday	59.91	0.000	0.000	0.000	456.851	457.108	3968.044	12262.720	3.73%
4/4/2016	Monday	43.94	135.080	74.658	3.364	494.790	783.174		12387.690	6.32%
4/5/2016	Tuesday	41.84	98.222	61.237	3.410	495.257	715.959		12521.090	5.72%
4/6/2016	Wednesday	45.82	86.681	50.331	3.263	463.745	663.737		11968.350	5.55%
4/7/2016	Thursday	42.41	92.037	53.080	3.410	451.051	654.565		12210.190	5.36%
4/8/2016	Friday	39.00	86.008	52.739	3.093	442.610	638.236		12364.460	5.16%
4/9/2016	Saturday	36.18	0.000	0.000	0.000	442.098	442.444		11641.370	3.80%
4/10/2016	Sunday	53.65	0.000	0.000	0.000	0.000	0.000		11233.340	
4/11/2016	Monday	42.98	0.000	0.000	0.000	0.000	0.000		12421.750	
4/12/2016	Tuesday	42.19	0.000	0.000	0.000	0.000	0.000		12933.370	
4/13/2016	Wednesday	54.51	0.000	0.000	0.000	0.000	0.000		13390.930	
4/14/2016	Thursday	59.00	0.000	0.000	0.000	0.000	0.000		13531.030	
4/15/2016	Friday	62.83	0.000	0.000	0.000	0.000	0.000		13638.830	

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
4/16/2016	Saturday	67.59	0.000	0.000	0.000	0.000	0.000		11978.040	
5/1/2016	Sunday	46.15	0.000	0.000	0.000	458.202	458.574	3955.355	11083.080	4.14%
5/2/2016	Monday	51.34	68.128	42.872	3.374	457.483	612.245		12878.830	4.75%
5/3/2016	Tuesday	55.25	74.840	48.518	3.417	453.303	630.996		13477.820	4.68%
5/4/2016	Wednesday	58.26	73.414	46.647	3.415	459.898	630.061		12988.570	4.85%
5/5/2016	Thursday	55.48	72.257	42.897	3.430	452.125	615.149		13460.980	4.57%
5/6/2016	Friday	68.25	73.544	47.516	3.863	450.436	624.299		13875.040	4.50%
5/7/2016	Saturday	64.48	0.000	0.000	0.000	435.562	435.917		12163.140	3.58%
5/8/2016	Sunday	61.86	0.000	0.000	0.000	453.959	454.299	4119.168	11669.380	3.89%
5/9/2016	Monday	59.89	83.511	51.581	6.206	467.739	669.697		13124.480	5.10%
5/10/2016	Tuesday	65.08	79.262	45.998	5.109	439.885	625.249		14300.630	4.37%
5/11/2016	Wednesday	60.34	74.866	43.952	6.491	466.085	643.958		13204.570	4.88%
5/12/2016	Thursday	56.41	75.193	44.555	5.395	456.857	634.679		13063.460	4.86%
5/13/2016	Friday	50.25	74.447	43.461	3.948	477.726	652.825		12550.450	5.20%
5/14/2016	Saturday	47.49	0.000	0.000	0.000	482.520	482.858		11523.780	4.19%
5/29/2016	Sunday	70.28	179.466	70.897	9.773	414.345	922.003	4159.967	14303.580	6.45%
5/30/2016	Monday	74.11	177.523	66.429	10.053	399.972	903.110		15735.460	5.74%
5/31/2016	Tuesday	69.26	137.202	58.083	10.110	327.831	765.116		16329.990	4.69%
6/1/2016	Wednesday	66.56	113.708	52.202	9.981	266.706	603.291		14958.090	4.03%
6/2/2016	Thursday	67.42	108.889	47.959	9.932	262.470	587.698		14796.940	3.97%
6/3/2016	Friday	74.59	105.077	48.012	9.894	255.666	575.873		15912.500	3.62%
6/4/2016	Saturday	69.47	97.286	47.585	10.039	258.824	563.049		14845.940	3.79%
6/5/2016	Sunday	72.66	0.000	0.000	0.000	0.000	0.000		14770.740	
6/6/2016	Monday	73.21	0.000	0.000	0.000	0.000	0.000		15644.770	
6/7/2016	Tuesday	67.77	0.000	0.000	0.000	0.000	0.000		14051.880	
6/8/2016	Wednesday	73.18	0.000	0.000	0.000	0.000	0.000		14460.000	
6/9/2016	Thursday	82.17	0.000	0.000	0.000	0.000	0.000		15674.880	
6/10/2016	Friday	84.07	0.000	0.000	0.000	0.000	0.000		15816.100	

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
6/11/2016	Saturday	79.23	0.000	0.000	0.000	0.000	0.000		13712.050	
6/26/2016	Sunday	80.03	67.301	41.836	8.945	255.132	530.041		14553.560	3.64%
6/27/2016	Monday	80.20	111.278	58.634	9.458	256.544	671.893		16053.980	4.19%
6/28/2016	Tuesday	75.10	101.808	53.730	8.511	256.548	641.761		15750.200	4.07%
6/29/2016	Wednesday	71.02	80.574	36.230	7.007	256.666	549.384		15250.850	3.60%
6/30/2016	Thursday	72.76	72.636	33.642	6.375	256.662	524.669		15313.720	3.43%
7/1/2016	Friday	69.89	85.573	37.981	5.834	267.299	571.021		14269.000	4.00%
7/2/2016	Saturday	65.27	0.000	0.000	0.000	262.755	263.147		12389.910	2.12%
7/3/2016	Sunday	66.40	45.800	22.194	3.453	279.710	455.880		12885.180	3.54%
7/4/2016	Monday	67.91	58.212	20.798	4.850	264.700	473.329		14198.250	3.33%
7/5/2016	Tuesday	79.95	85.137	44.706	9.027	262.339	574.111		16053.170	3.58%
7/6/2016	Wednesday	81.12	88.013	39.980	16.149	265.303	574.871		16150.830	3.56%
7/7/2016	Thursday	74.90	88.999	37.442	19.406	265.858	580.098		15983.000	3.63%
7/8/2016	Friday	78.90	97.712	46.056	21.082	264.834	612.025		15950.230	3.84%
7/9/2016	Saturday	76.93	85.812	41.464	18.221	262.318	583.749		15312.360	3.81%
7/24/2016	Sunday	83.14	63.390	46.471	14.875	428.186	718.167	3871.832		
7/25/2016	Monday	80.03	97.069	55.580	22.835	431.103	829.936			
7/26/2016	Tuesday	78.96	92.216	51.880	21.966	429.865	805.851			
7/27/2016	Wednesday	78.23	88.262	44.432	21.107	430.077	763.496			
7/28/2016	Thursday	75.64	78.240	46.671	21.497	430.093	749.022			
7/29/2016	Friday	69.10	59.076	37.399	20.607	429.960	691.495			
7/30/2016	Saturday	73.15	0.000	0.000	0.000	429.708	429.973			
7/31/2016	Sunday	76.99	0.000	29.457	12.658	429.102	599.330			
8/1/2016	Monday	72.74	0.000	37.614	20.197	426.598	652.128			
8/2/2016	Tuesday	73.74	0.000	37.764	19.763	428.617	634.773			
8/3/2016	Wednesday	77.35	0.000	48.483	19.743	419.567	664.493			
8/4/2016	Thursday	84.03	0.000	48.545	21.259	415.532	666.591			
8/5/2016	Friday	75.92	0.000	40.730	21.004	344.000	557.194			

TTR										
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-4 Total**	**AHU-9 Total**	**AHU-12 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
8/6/2016	Saturday	74.07	0.000	33.697	24.502	425.117	580.793			
8/21/2016	Sunday	67.93	0.000	24.577	11.135	438.079	536.097			
8/22/2016	Monday	71.16	0.000	41.529	19.368	433.755	603.128		14458.437	4.17%
8/23/2016	Tuesday	74.55	0.000	42.300	21.102	425.938	596.291		1282.300	
8/24/2016	Wednesday	75.53	0.000	43.251	21.391	427.583	598.808		1348.010	
8/25/2016	Thursday	71.47	0.000	36.521	20.281	427.900	576.403		1245.470	
8/26/2016	Friday	67.47	0.000	34.231	19.857	431.966	570.022		1066.270	
8/27/2016	Saturday	70.50	0.000	34.365	6.265	430.702	552.794		407.670	
8/28/2016	Sunday	77.16	0.000	0.000	0.000	0.000	0.000		13955.934	
8/29/2016	Monday	76.15	0.000	0.000	0.000	0.000	0.000		15559.150	
8/30/2016	Tuesday	75.72	0.000	0.000	0.000	0.000	0.000		15508.678	
8/31/2016	Wednesday	73.97	0.000	0.000	0.000	0.000	0.000		15395.866	
9/1/2016	Thursday	70.34	0.000	0.000	0.000	0.000	0.000		14750.393	
9/2/2016	Friday	68.12	0.000	0.000	0.000	0.000	0.000		14033.639	
9/3/2016	Saturday	68.84	0.000	0.000	0.000	0.000	0.000		13635.251	

Site #2:

FIXED STATIC PRESSURE									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
8/22/2015	SATURDAY	70.6	3.592	0.395	19.893	23.879		531.406	
8/23/2015	SUNDAY	68.4	1.334	0.396	19.853	21.583		522.336	
8/24/2015	MONDAY	63.4	2.901	60.964	50.317	114.181		738.241	
8/25/2015	TUESDAY	63.2	1.694	57.636	50.082	109.412		744.621	
8/26/2015	WEDNESDAY	64.7	1.709	44.962	47.341	94.013		751.771	
8/27/2015	THURSDAY	64.0	1.716	52.925	50.805	105.447		814.277	
8/28/2015	FRIDAY	66.4	2.988	42.554	41.783	87.326		873.227	
8/29/2015	SATURDAY	70.6	7.200	84.860	56.232	148.292		1270.558	
8/30/2015	SUNDAY	69.4	7.907	82.319	56.173	146.398		1352.355	
8/31/2015	MONDAY	75.7	3.328	41.964	36.497	81.789		1004.503	
9/1/2015	TUESDAY	80.7	2.017	44.931	35.131	82.079		1065.810	
9/2/2015	WEDNESDAY	76.8	1.957	44.477	44.638	91.072		1057.320	
9/3/2015	THURSDAY	80.0	2.167	50.475	47.773	100.415		1150.080	
9/4/2015	FRIDAY	80.4	3.712	41.948	44.515	90.176		1198.226	
9/19/2015	SATURDAY	61.7	6.960	120.069	97.625	224.655	1040.928		
9/20/2015	SUNDAY	59.8	0.000	0.402	63.985	64.387			
9/21/2015	MONDAY	63.3	2.901	60.981	84.140	148.023			
9/22/2015	TUESDAY	67.6	2.552	60.751	85.224	148.526			
9/23/2015	WEDNESDAY	69.4	2.045	60.849	83.651	146.546			
9/24/2015	THURSDAY	68.7	2.199	71.107	89.028	162.333			
9/25/2015	FRIDAY	67.6	1.667	59.556	85.236	146.459			
9/26/2015	SATURDAY	67.3	0.913	0.398	63.698	65.009	908.033		
9/27/2015	SUNDAY	67.3	0.842	0.391	63.687	64.920			
9/28/2015	MONDAY	69.1	3.918	63.867	85.833	153.618			
9/29/2015	TUESDAY	60.6	1.907	63.826	90.817	156.550			
9/30/2015	WEDNESDAY	54.5	1.732	64.231	83.799	149.761			
10/1/2015	THURSDAY	53.5	1.987	78.344	87.596	167.928			

FIXED STATIC PRESSURE									
Date		Average Daily Temp.	RTU-1 Total	RTU-3 Total	RTU-4 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
10/2/2015	FRIDAY	54.2	2.168	64.747	83.333	150.247			
10/17/2015	SATURDAY	41.4	0.005	81.612	53.943	135.559	1067.970	746.300	18.16%
10/18/2015	SUNDAY	47.0	0.262	10.704	55.056	66.021		487.960	13.53%
10/19/2015	MONDAY	62.4	3.896	90.671	82.373	176.940		797.800	22.18%
10/20/2015	TUESDAY	63.9	2.153	65.788	81.752	149.693		755.700	19.81%
10/21/2015	WEDNESDAY	65.7	2.196	60.557	80.420	143.174		806.330	17.76%
10/22/2015	THURSDAY	58.8	1.941	77.780	87.425	167.147		693.270	24.11%
10/23/2015	FRIDAY	59.5	6.687	121.169	101.580	229.437		1226.470	18.71%
10/24/2015	SATURDAY	56.2	6.519	117.766	98.586	222.871	1149.266	981.950	22.70%
10/25/2015	SUNDAY	47.7	0.007	6.867	60.595	67.469		480.090	14.05%
10/26/2015	MONDAY	49.9	3.703	84.291	82.477	170.470		712.210	23.94%
10/27/2015	TUESDAY	49.9	2.495	77.902	83.806	164.203		720.130	22.80%
10/28/2015	WEDNESDAY	48.1	2.010	79.553	81.182	162.745		691.650	23.53%
10/29/2015	THURSDAY	43.5	3.048	102.497	86.021	191.566		740.130	25.88%
10/30/2015	FRIDAY	43.0	3.006	85.547	81.388	169.942		672.830	25.26%
11/14/2015	SATURDAY	47.7	0.794	79.905	8.099	88.798	1010.424	513.230	17.30%
11/15/2015	SUNDAY	55.3	0.008	79.132	0.300	79.440		502.380	15.81%
11/16/2015	MONDAY	51.5	3.521	103.142	58.990	165.653		685.240	24.17%
11/17/2015	TUESDAY	56.9	2.026	103.692	61.926	167.644		749.410	22.37%
11/18/2015	WEDNESDAY	51.9	2.022	99.370	56.285	157.677		662.430	23.80%
11/19/2015	THURSDAY	40.8	2.508	111.339	68.417	182.264		707.220	25.77%
11/20/2015	FRIDAY	35.8	2.948	107.538	58.462	168.948		765.870	22.06%
11/21/2015	SATURDAY	25.8	5.171	78.051	56.339	139.562	1150.500	607.180	22.99%
11/22/2015	SUNDAY	21.8	6.919	78.857	60.440	146.216		622.090	23.50%
11/23/2015	MONDAY	34.7	5.967	116.981	79.699	202.647		779.730	25.99%
11/24/2015	TUESDAY	35.3	3.767	111.111	74.259	189.137		747.690	25.30%
11/25/2015	WEDNESDAY	47.6	2.965	111.054	70.280	184.299		707.860	26.04%
11/26/2015	THURSDAY	52.1	0.010	74.756	0.300	75.066		519.360	

FIXED STATIC PRESSURE									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
11/27/2015	FRIDAY	36.5	3.823	80.077	55.836	139.735		601.410	23.23%
12/12/2015	SATURDAY	53.0	0.013	75.280	6.071	81.364	1071.421	476.510	17.07%
12/13/2015	SUNDAY	60.3	0.010	72.448	0.301	72.759		571.800	12.72%
12/14/2015	MONDAY	47.4	3.075	110.847	56.252	170.174		720.770	23.61%
12/15/2015	TUESDAY	39.8	2.278	107.885	61.545	171.709		712.930	24.08%
12/16/2015	WEDNESDAY	41.1	2.386	109.268	68.331	179.985		710.580	25.33%
12/17/2015	THURSDAY	32.1	2.741	117.248	80.634	200.623		766.610	26.17%
12/18/2015	FRIDAY	28.0	3.350	113.338	78.119	194.807		782.240	24.90%
12/19/2015	SATURDAY	25.3	5.023	79.665	61.656	146.344	1236.499	631.970	23.16%
12/20/2015	SUNDAY	44.7	4.771	80.110	61.153	146.034		609.560	23.96%
12/21/2015	MONDAY	43.6	4.696	121.868	76.693	203.257		761.460	26.69%
12/22/2015	TUESDAY	36.8	2.996	115.595	79.887	198.478		753.140	26.35%
12/23/2015	WEDNESDAY	49.0	2.464	115.517	73.559	191.541		720.840	26.57%
12/24/2015	THURSDAY	37.2	2.404	114.559	0.871	117.834		655.740	
12/25/2015	FRIDAY	33.7	2.602	77.854	0.320	80.776		536.560	
1/9/2016	SATURDAY	21.9	6.737	127.764	0.315	134.816		986.550	
1/10/2016	SUNDAY	4.4	6.805	126.858	0.317	133.980		987.920	
1/11/2016	MONDAY	19.1	3.306	79.561	0.311	83.178		676.580	
1/12/2016	TUESDAY	10.2	2.388	81.301	0.314	84.003		703.660	
1/13/2016	WEDNESDAY	22.6	2.608	85.505	0.304	88.417		673.570	
1/14/2016	THURSDAY	40.0	2.497	95.647	0.308	98.452		660.600	
1/15/2016	FRIDAY	29.6	4.222	111.506	74.493	190.221		898.050	
1/16/2016	SATURDAY	16.5	0.027	0.426	0.287	0.740		502.590	
1/17/2016	SUNDAY	1.5	0.040	0.444	0.295	0.780		527.510	
1/18/2016	MONDAY	3.2	0.040	0.448	0.295	0.784		537.570	
1/19/2016	TUESDAY	10.8	3.698	90.360	10.362	104.419		739.920	
1/20/2016	WEDNESDAY	14.2	3.293	86.235	0.306	89.833		686.520	
1/21/2016	THURSDAY	20.6	3.119	94.626	0.309	98.054		708.670	

FIXED STATIC PRESSURE									
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mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
1/22/2016	FRIDAY	25.0	3.381	81.991	0.307	85.679			
2/6/2016	SATURDAY	34.2	6.427	137.805	110.740	254.972	1169.126		
2/7/2016	SUNDAY	40.0	6.282	127.620	103.085	236.988			
2/8/2016	MONDAY	21.8	3.129	67.406	54.395	124.930			
2/9/2016	TUESDAY	15.7	1.939	69.481	59.268	130.688			
2/10/2016	WEDNESDAY	14.6	1.734	71.129	61.885	134.748			
2/11/2016	THURSDAY	17.9	1.900	82.300	71.860	156.059			
2/12/2016	FRIDAY	20.1	1.948	69.494	59.299	130.742			
2/13/2016	SATURDAY	13.0	0.039	0.426	0.287	0.752	595.089		
2/14/2016	SUNDAY	19.5	0.043	0.442	0.293	0.778			
2/15/2016	MONDAY	26.0	0.028	0.412	0.280	0.720			
2/16/2016	TUESDAY	30.2	2.740	79.084	65.986	147.810			
2/17/2016	WEDNESDAY	32.8	2.014	75.907	63.137	141.057			
2/18/2016	THURSDAY	39.1	2.183	88.240	72.935	163.359			
2/19/2016	FRIDAY	51.7	1.672	82.921	56.020	140.613			
3/5/2016	SATURDAY	35.9	0.022	0.415	0.294	0.732	647.747		
3/6/2016	SUNDAY	42.7	0.025	0.398	0.283	0.706			
3/7/2016	MONDAY	59.5	3.426	74.282	56.842	134.549			
3/8/2016	TUESDAY	63.8	1.657	70.576	55.297	127.530			
3/9/2016	WEDNESDAY	50.9	1.391	66.080	46.640	114.111			
3/10/2016	THURSDAY	47.1	1.460	78.579	65.551	145.589			
3/11/2016	FRIDAY	47.3	1.678	68.798	54.055	124.530			
3/12/2016	SATURDAY	46.6	6.444	126.174	110.094	242.712	1298.704		
3/13/2016	SUNDAY	51.3	5.724	112.789	108.587	227.101			
3/14/2016	MONDAY	53.9	2.595	63.607	55.703	121.905			
3/15/2016	TUESDAY	57.0	1.382	60.705	55.243	117.330			
3/16/2016	WEDNESDAY	51.5	1.521	72.550	60.265	134.337			
3/17/2016	THURSDAY	47.6	5.869	124.821	103.896	234.585			

FIXED STATIC PRESSURE										
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mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
3/18/2016	FRIDAY	38.9	5.689	117.270	97.775	220.734			
4/2/2016	SATURDAY	39.0	5.988	127.553	101.489	235.029	1082.587	801.950	29.31%
4/3/2016	SUNDAY	55.6	6.179	124.942	99.889	231.011		915.650	25.23%
4/4/2016	MONDAY	43.5	2.281	60.681	49.303	112.265		607.590	18.48%
4/5/2016	TUESDAY	39.3	1.550	66.756	52.537	120.843		644.390	18.75%
4/6/2016	WEDNESDAY	48.7	1.423	66.865	50.407	118.695		617.010	19.24%
4/7/2016	THURSDAY	43.9	1.523	78.484	61.762	141.769		661.580	21.43%
4/8/2016	FRIDAY	40.0	1.674	69.090	52.212	122.975		637.110	19.30%
4/9/2016	SATURDAY	36.1	5.769	127.049	101.367	234.185	1056.148	803.320	29.15%
4/10/2016	SUNDAY	49.1	5.785	122.919	96.984	225.689		773.270	29.19%
4/11/2016	MONDAY	44.9	2.482	62.351	49.464	114.298		639.140	17.88%
4/12/2016	TUESDAY	42.4	1.450	64.169	50.857	116.475		627.600	18.56%
4/13/2016	WEDNESDAY	50.9	1.475	66.417	50.943	118.836		642.690	18.49%
4/14/2016	THURSDAY	54.8	1.382	75.104	59.581	136.066		701.070	19.41%
4/15/2016	FRIDAY	61.1	1.416	60.447	48.736	110.599		706.320	15.66%
4/30/2016	SATURDAY	48.4	0.016	0.384	0.282	0.682	721.308	429.250	0.16%
5/1/2016	SUNDAY	48.5	0.021	0.377	0.272	0.671		399.930	0.17%
5/2/2016	MONDAY	52.8	2.166	71.656	51.198	125.021		613.190	20.39%
5/3/2016	TUESDAY	58.0	1.495	65.401	49.467	116.363		637.520	18.25%
5/4/2016	WEDNESDAY	56.2	1.403	66.324	48.056	115.783		605.670	19.12%
5/5/2016	THURSDAY	54.9	1.305	76.814	60.078	138.197		641.250	21.55%
5/6/2016	FRIDAY	67.6	6.194	121.202	95.922	223.319		964.560	23.15%
5/7/2016	SATURDAY	67.9	6.765	118.055	96.891	221.711	1029.705	1114.170	19.90%
5/8/2016	SUNDAY	60.6	5.664	120.779	96.336	222.779		848.020	26.27%
5/9/2016	MONDAY	60.3	2.614	59.204	49.761	111.579		762.520	14.63%
5/10/2016	TUESDAY	65.0	1.495	57.652	47.930	107.076		861.020	12.44%
5/11/2016	WEDNESDAY	65.1	1.456	60.401	50.715	112.573		799.000	14.09%
5/12/2016	THURSDAY	61.1	1.486	78.171	61.583	141.239		680.980	20.74%

FIXED STATIC PRESSURE										
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mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
5/13/2016	FRIDAY	54.9	1.513	62.723	48.512	112.748		664.670	16.96%
5/28/2016	SATURDAY	72.0	1.627	24.384	22.731	48.742	630.712	785.720	6.20%
5/29/2016	SUNDAY	72.5	0.000	0.374	0.292	0.666		587.920	0.11%
5/30/2016	MONDAY	74.3	0.000	0.368	0.294	0.662		568.320	0.12%
5/31/2016	TUESDAY	72.3	1.321	35.028	30.684	67.033		767.870	8.73%
6/1/2016	WEDNESDAY	70.8	1.634	59.233	52.323	113.191		959.400	11.80%
6/2/2016	THURSDAY	69.8	5.610	89.100	89.508	184.219		1140.540	16.15%
6/3/2016	FRIDAY	73.2	7.240	108.246	100.712	216.198		1453.240	14.88%
6/4/2016	SATURDAY	72.2	10.300	103.098	97.432	210.830		1419.200	14.86%
6/5/2016	SUNDAY	72.9	7.516	105.681	95.768	208.965		1222.200	17.10%
6/6/2016	MONDAY	72.8	0.001	0.380	0.291	0.672		482.390	
6/7/2016	TUESDAY	65.2	0.002	0.346	0.264	0.613		336.990	
6/8/2016	WEDNESDAY	68.7	0.006	0.334	0.253	0.592		320.640	
6/9/2016	THURSDAY	76.9	0.001	0.325	0.257	0.584		330.490	
6/10/2016	FRIDAY	82.7	0.000	0.219	0.175	0.395		468.800	
6/25/2016	SATURDAY	82.2	0.000	0.355	0.292	0.647	564.768	567.180	0.11%
6/26/2016	SUNDAY	80.9	0.000	0.354	0.292	0.646		630.100	0.10%
6/27/2016	MONDAY	78.6	3.247	64.438	46.281	113.966		1080.560	10.55%
6/28/2016	TUESDAY	69.7	1.418	42.727	41.547	85.691		942.000	9.10%
6/29/2016	WEDNESDAY	67.5	1.642	59.593	64.495	125.730		818.410	15.36%
6/30/2016	THURSDAY	68.3	1.788	64.809	64.241	130.838		925.380	14.14%
7/1/2016	FRIDAY	67.7	1.700	55.472	50.078	107.249		859.260	12.48%
7/2/2016	SATURDAY	63.7	0.001	0.342	0.259	0.601	459.458	401.820	0.15%
7/3/2016	SUNDAY	64.8	0.003	0.344	0.263	0.611		404.600	0.15%
7/4/2016	MONDAY	70.0	0.001	0.337	0.261	0.599		386.790	0.15%
7/5/2016	TUESDAY	78.6	1.921	59.396	59.867	121.184		1020.950	11.87%
7/6/2016	WEDNESDAY	75.6	1.412	57.369	47.143	105.924		1009.390	10.49%
7/7/2016	THURSDAY	74.7	1.834	64.852	65.242	131.929		1035.490	12.74%

FIXED STATIC PRESSURE									
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mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
7/8/2016	FRIDAY	76.4	1.936	50.200	46.475	98.611		987.990	9.98%
7/23/2016	SATURDAY	83.7	0.000	0.325	0.261	0.586	893.159	548.050	0.11%
7/24/2016	SUNDAY	83.5	0.000	0.324	0.263	0.587		532.860	0.11%
7/25/2016	MONDAY	76.7	3.691	89.103	183.061	275.855		1319.520	20.91%
7/26/2016	TUESDAY	76.2	1.967	58.391	100.264	160.623		1211.660	13.26%
7/27/2016	WEDNESDAY	76.4	2.045	59.523	85.804	147.372		1173.790	12.56%
7/28/2016	THURSDAY	74.9	2.041	60.975	87.193	150.209		1179.100	12.74%
7/29/2016	FRIDAY	72.2	1.887	57.321	98.718	157.926		1124.980	14.04%
7/30/2016	SATURDAY	73.2	0.000	0.359	78.534	78.893	861.134	816.350	9.66%
7/31/2016	SUNDAY	74.1	0.000	0.359	59.648	60.007		829.300	7.24%
8/1/2016	MONDAY	75.1	2.464	60.375	59.945	122.784		1270.132	9.67%
8/2/2016	TUESDAY	76.0	1.560	48.165	73.911	123.636		1180.688	10.47%
8/3/2016	WEDNESDAY	79.6	2.002	55.291	80.341	137.633		1226.970	11.22%
8/4/2016	THURSDAY	79.1	2.125	66.210	80.906	149.242		1309.660	11.40%
8/5/2016	FRIDAY	75.2	7.611	99.006	82.322	188.939		1347.480	14.02%
8/20/2016	SATURDAY	70.1	0.000	0.342	0.270	0.612	632.178	478.160	0.13%
8/21/2016	SUNDAY	67.0	0.001	0.342	0.264	0.607		574.010	0.11%
8/22/2016	MONDAY	75.1	2.611	36.582	30.428	69.621		833.561	8.35%
8/23/2016	TUESDAY	71.7	2.367	45.452	30.397	78.216		804.968	9.72%
8/24/2016	WEDNESDAY	78.0	2.595	51.620	24.652	78.867		975.463	8.09%
8/25/2016	THURSDAY	72.4	6.253	91.856	79.036	177.145		1105.660	16.02%
8/26/2016	FRIDAY	71.7	7.835	116.543	102.731	227.109		1133.841	20.03%
8/27/2016	SATURDAY	76.2	8.001	119.282	107.157	234.439	972.262	1294.718	18.11%
8/28/2016	SUNDAY	77.5	8.986	122.263	110.495	241.744		1348.539	17.93%
8/29/2016	MONDAY		2.427	36.261	30.490	69.178		945.999	7.31%
8/30/2016	TUESDAY		2.397	35.997	23.883	62.278		950.929	6.55%
8/31/2016	WEDNESDAY	73.1	3.175	53.949	49.358	106.481		924.525	11.52%
9/1/2016	THURSDAY	66.8	2.466	73.674	65.458	141.598		907.283	15.61%

FIXED STATIC PRESSURE									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
9/2/2016	FRIDAY	66.0	2.868	59.077	54.599	116.544		842.534	13.83%
9/17/2016	SATURDAY	70.2	7.743	112.613	106.260	226.616	1036.555	1510.925	15.00%
9/18/2016	SUNDAY	68.4	7.327	117.905	113.052	238.284		1346.381	17.70%
9/19/2016	MONDAY	73.2	2.978	56.634	50.567	110.180		861.101	12.80%
9/20/2016	TUESDAY	75.3	3.161	55.981	51.119	110.260		950.401	11.60%
9/21/2016	WEDNESDAY	74.8	3.244	55.285	51.930	110.459		973.777	11.34%
9/22/2016	THURSDAY	74.6	3.163	65.684	61.637	130.484		1027.281	12.70%
9/23/2016	FRIDAY	73.0	3.258	55.109	51.905	110.272		977.538	11.28%
9/24/2016	SATURDAY	74.0	0.000	0.343	0.268	0.611		513.080	0.12%
9/25/2016	SUNDAY	71.7	0.000	0.342	0.268	0.609		513.126	0.12%
9/26/2016	MONDAY	62.7	0.000	46.150	58.845	104.995		742.993	14.13%
9/27/2016	TUESDAY	62.8	0.000	60.709	54.078	114.787		681.927	16.83%
9/28/2016	WEDNESDAY	58.0	0.000	65.214	52.869	118.082		618.887	19.08%
9/29/2016	THURSDAY	63.5	0.000	71.574	62.559	134.133		747.891	17.93%
9/30/2016	FRIDAY	60.8	0.000	56.760	50.328	107.087			

Site #2:

TTR									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
9/5/2015	SATURDAY	81.2	6.513	76.519	25.634	108.667		1594.792	
9/6/2015	SUNDAY	82.7	0.000	0.349	3.980	4.329		450.320	
9/7/2015	MONDAY	78.7	4.134	39.620	20.409	64.162		1148.180	
9/8/2015	TUESDAY	75.3	3.177	38.690	18.382	60.249		1114.097	
9/9/2015	WEDNESDAY	72.1	2.519	38.310	13.996	54.825			
9/10/2015	THURSDAY	70.7	2.730	45.412	42.565	90.707			
9/11/2015	FRIDAY	62.8	1.519	43.113	54.846	99.479			
9/12/2015	SATURDAY	57.7	5.070	79.538	60.898	145.506	769.073		
9/13/2015	SUNDAY	59.6	5.281	77.100	60.579	142.961			
9/14/2015	MONDAY	71.5	2.530	40.927	54.855	98.313			
9/15/2015	TUESDAY	74.9	1.779	40.211	53.964	95.954			
9/16/2015	WEDNESDAY	75.9	2.237	39.053	53.791	95.080			
9/17/2015	THURSDAY	76.4	3.547	44.049	54.024	101.620			
9/18/2015	FRIDAY	70.5	2.635	37.941	49.063	89.639			
10/3/2015	SATURDAY	53.2	5.019	85.463	59.788	150.270	792.604		
10/4/2015	SUNDAY	55.1	5.026	79.386	58.169	142.582			
10/5/2015	MONDAY	59.2	2.229	42.422	53.867	98.517			
10/6/2015	TUESDAY	64.4	1.553	42.635	54.815	99.003		842.910	11.75%
10/7/2015	WEDNESDAY	66.5	1.946	41.986	53.209	97.141		870.700	11.16%
10/8/2015	THURSDAY	66.1	1.548	48.022	54.039	103.610		796.730	13.00%
10/9/2015	FRIDAY	56.1	1.490	46.283	53.708	101.481		630.010	16.11%
10/10/2015	SATURDAY	52.3	0.010	0.412	43.248	43.671	581.417	442.620	9.87%
10/11/2015	SUNDAY	66.7	0.006	0.388	42.624	43.017		456.620	9.42%
10/12/2015	MONDAY	67.8	0.928	0.389	42.619	43.936		460.670	9.54%
10/13/2015	TUESDAY	56.3	1.420	55.389	53.846	110.655		676.840	16.35%
10/14/2015	WEDNESDAY	54.0	1.592	60.801	54.266	116.659		750.960	15.53%
10/15/2015	THURSDAY	57.7	0.001	82.382	44.559	126.942		956.360	13.27%

TTR									
Date		Average Daily Temp.	RTU-1 Total	RTU-3 Total	RTU-4 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
10/16/2015	FRIDAY	45.7	1.454	42.841	52.242	96.536		634.500	15.21%
10/31/2015	SATURDAY	50.3	0.005	58.468	43.087	101.560	681.037	507.910	20.00%
11/1/2015	SUNDAY	55.6	1.084	29.212	43.379	73.675		495.960	14.86%
11/2/2015	MONDAY	56.4	3.127	54.652	55.851	113.631		701.630	16.20%
11/3/2015	TUESDAY	51.3	1.816	44.445	53.184	99.444		611.950	16.25%
11/4/2015	WEDNESDAY	57.5	1.540	44.941	52.839	99.320		751.550	13.22%
11/5/2015	THURSDAY	59.7	1.688	48.611	52.858	103.157		815.820	12.64%
11/6/2015	FRIDAY	46.3	1.541	42.677	46.032	90.250		626.860	14.40%
11/7/2015	SATURDAY	42.1	5.131	83.323	57.950	146.404	815.476	949.960	15.41%
11/8/2015	SUNDAY	39.2	5.347	75.657	58.337	139.341		867.140	16.07%
11/9/2015	MONDAY	39.0	2.501	65.935	34.723	103.159		627.230	16.45%
11/10/2015	TUESDAY	43.2	2.014	69.157	37.105	108.276		649.530	16.67%
11/11/2015	WEDNESDAY	55.1	0.015	48.584	0.291	48.890		457.600	
11/12/2015	THURSDAY	46.3	2.084	76.523	42.099	120.706		650.890	18.54%
11/13/2015	FRIDAY	40.0	1.858	71.239	36.249	109.346		640.720	17.07%
11/28/2015	SATURDAY	32.7	4.421	74.313	45.923	124.657	1024.551	599.087	20.81%
11/29/2015	SUNDAY	34.4	4.100	76.212	46.186	126.498		592.566	21.35%
11/30/2015	MONDAY	38.7	4.891	103.764	68.299	176.954		759.976	23.28%
12/1/2015	TUESDAY	36.7	2.778	90.605	59.604	152.987		727.670	21.02%
12/2/2015	WEDNESDAY	33.2	3.005	88.042	57.987	149.034		715.000	20.84%
12/3/2015	THURSDAY	34.6	2.954	90.843	63.292	157.090		705.530	22.27%
12/4/2015	FRIDAY	35.3	3.144	83.120	51.066	137.330		690.250	19.90%
12/5/2015	SATURDAY	38.5	5.564	89.368	78.635	173.568	945.878	894.800	19.40%
12/6/2015	SUNDAY	35.7	5.064	89.516	67.073	161.653		831.860	19.43%
12/7/2015	MONDAY	38.1	2.435	71.248	39.878	113.561		661.570	17.17%
12/8/2015	TUESDAY	37.3	2.304	78.840	49.966	131.110		681.560	19.24%
12/9/2015	WEDNESDAY	42.7	2.080	75.370	44.280	121.731		644.370	18.89%
12/10/2015	THURSDAY	50.5	1.761	79.550	47.536	128.847		662.920	19.44%

TTR										
Date		Average Daily Temp.	RTU-1 Total	RTU-3 Total	RTU-4 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
12/11/2015	FRIDAY	46.4	1.799	74.277	39.333	115.409		622.370	18.54%
12/26/2015	SATURDAY	38.8	3.730	74.433	0.320	78.483		536.990	
12/27/2015	SUNDAY	36.0	3.844	75.958	0.319	80.120		540.300	
12/28/2015	MONDAY	33.0	5.552	103.737	0.317	109.607		719.660	
12/29/2015	TUESDAY	28.3	2.944	87.392	0.324	90.661		690.720	
12/30/2015	WEDNESDAY	27.6	3.159	92.252	0.316	95.727		663.060	
12/31/2015	THURSDAY	25.5	2.761	94.196	0.318	97.275		676.610	
1/1/2016	FRIDAY	28.0	3.502	74.130	0.319	77.951		562.270	
1/2/2016	SATURDAY	25.5	4.012	75.008	0.320	79.340		565.220	
1/3/2016	SUNDAY	25.0	3.617	77.257	0.319	81.192		583.500	
1/4/2016	MONDAY	26.2	4.857	111.570	0.319	116.746		740.220	
1/5/2016	TUESDAY	25.6	3.509	101.400	0.322	105.231		692.280	
1/6/2016	WEDNESDAY	31.0	2.321	94.934	0.315	97.569		664.340	
1/7/2016	THURSDAY	36.6	2.634	96.285	0.320	99.238		685.330	
1/8/2016	FRIDAY	38.3	5.112	95.833	0.318	101.264		751.390	
1/23/2016	SATURDAY	22.9	0.028	0.413	0.289	0.729			
1/24/2016	SUNDAY	29.7	0.029	0.409	0.286	0.724			
1/25/2016	MONDAY	31.6	4.485	85.753	0.307	90.545			
1/26/2016	TUESDAY	28.4	2.340	78.463	0.303	81.106			
1/27/2016	WEDNESDAY	33.2	2.395	71.168	0.305	73.867			
1/28/2016	THURSDAY	36.1	2.471	75.010	0.317	77.799			
1/29/2016	FRIDAY	32.2	2.238	64.930	0.305	67.473			
1/30/2016	SATURDAY	38.0	0.029	0.389	0.277	0.695	349.204		
1/31/2016	SUNDAY	36.8	0.024	0.397	0.280	0.702			
2/1/2016	MONDAY	32.4	3.364	77.063	0.302	80.729			
2/2/2016	TUESDAY	35.6	3.048	68.402	0.302	71.753			
2/3/2016	WEDNESDAY	29.4	2.378	61.233	40.795	104.406			
2/4/2016	THURSDAY	26.0	1.477	72.027	64.239	137.742			

TTR									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
2/5/2016	FRIDAY	27.2	1.544	57.829	50.090	109.463			
2/20/2016	SATURDAY	47.9	5.257	94.280	71.514	171.050	888.996		
2/21/2016	SUNDAY	38.5	4.833	82.459	67.793	155.085			
2/22/2016	MONDAY	35.2	2.042	45.696	37.405	85.143			
2/23/2016	TUESDAY	36.8	1.350	48.634	39.525	89.509			
2/24/2016	WEDNESDAY	38.1	1.369	51.674	41.050	94.092			
2/25/2016	THURSDAY	35.0	1.396	62.144	52.270	115.811			
2/26/2016	FRIDAY	33.5	5.778	93.576	78.951	178.305			
2/27/2016	SATURDAY	46.5	5.265	87.002	70.096	162.363	731.055		
2/28/2016	SUNDAY	51.1	0.012	0.409	0.295	0.716			
2/29/2016	MONDAY	43.2	2.102	56.195	38.785	97.082			
3/1/2016	TUESDAY	27.9	2.000	63.686	40.206	105.892			
3/2/2016	WEDNESDAY	25.9	2.121	67.194	44.526	113.841			
3/3/2016	THURSDAY	33.9	2.243	79.538	53.939	135.720			
3/4/2016	FRIDAY	35.7	2.287	68.112	45.042	115.441			
3/19/2016	SATURDAY	37.2	0.016	0.384	0.276	0.676	479.905		
3/20/2016	SUNDAY	40.1	0.022	0.388	0.277	0.687			
3/21/2016	MONDAY	42.4	2.358	55.887	41.905	100.150			
3/22/2016	TUESDAY	53.5	1.205	54.844	38.500	94.549			
3/23/2016	WEDNESDAY	45.0	1.155	46.620	36.900	84.675			
3/24/2016	THURSDAY	36.4	1.590	57.546	49.247	108.383			
3/25/2016	FRIDAY	38.8	1.432	49.403	39.951	90.786			
3/26/2016	SATURDAY	45.7	0.024	0.375	0.262	0.661	543.988		
3/27/2016	SUNDAY	43.2	0.015	0.383	0.261	0.659			
3/28/2016	MONDAY	47.2	1.973	59.269	42.822	104.064			
3/29/2016	TUESDAY	48.7	1.197	53.061	37.885	92.143			
3/30/2016	WEDNESDAY	57.6	1.217	48.331	35.237	84.785			
3/31/2016	THURSDAY	53.5	1.260	52.303	40.404	93.968			

TTR										
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mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
4/1/2016	FRIDAY	43.2	4.721	87.874	75.112	167.708			
4/16/2016	SATURDAY	65.4	0.007	0.338	0.242	0.587	390.636	381.250	0.15%
4/17/2016	SUNDAY	66.3	0.009	0.338	0.249	0.597		378.490	0.16%
4/18/2016	MONDAY	66.4	2.029	42.499	34.199	78.727		753.590	10.45%
4/19/2016	TUESDAY	61.3	1.266	40.482	33.273	75.021		793.580	9.45%
4/20/2016	WEDNESDAY	58.2	1.084	40.450	29.815	71.349		698.380	10.22%
4/21/2016	THURSDAY	54.0	1.101	48.338	36.330	85.769		648.160	13.23%
4/22/2016	FRIDAY	56.9	1.105	43.984	33.496	78.585		579.210	13.57%
4/23/2016	SATURDAY	57.4	0.014	0.366	0.271	0.651	404.141	429.510	0.15%
4/24/2016	SUNDAY	66.7	0.007	0.347	0.259	0.613		354.650	0.17%
4/25/2016	MONDAY	70.7	2.210	43.078	34.313	79.601		786.670	10.12%
4/26/2016	TUESDAY	57.6	1.172	45.108	35.966	82.247		600.380	13.70%
4/27/2016	WEDNESDAY	49.3	1.098	42.766	31.039	74.903		555.610	13.48%
4/28/2016	THURSDAY	53.7	1.092	52.811	38.149	92.053		565.170	16.29%
4/29/2016	FRIDAY	49.3	1.052	41.980	31.042	74.074		553.620	13.38%
5/14/2016	SATURDAY	47.5	4.904	94.055	61.159	160.118	687.343	836.570	19.14%
5/15/2016	SUNDAY	51.9	4.529	80.772	59.685	144.987		776.210	18.68%
5/16/2016	MONDAY	57.6	1.829	41.104	31.515	74.449		595.460	12.50%
5/17/2016	TUESDAY	54.8	1.065	41.829	31.459	74.353		538.170	13.82%
5/18/2016	WEDNESDAY	56.4	1.090	42.717	30.904	74.711		582.580	12.82%
5/19/2016	THURSDAY	60.1	1.189	47.726	37.122	86.037		635.040	13.55%
5/20/2016	FRIDAY	60.6	1.189	40.187	31.312	72.688		587.300	12.38%
5/21/2016	SATURDAY	63.5	0.006	0.345	0.259	0.609	382.022	355.930	0.17%
5/22/2016	SUNDAY	70.4	0.005	0.336	0.261	0.601		316.640	0.19%
5/23/2016	MONDAY	70.1	2.279	40.420	38.991	81.691		742.240	11.01%
5/24/2016	TUESDAY	75.2	1.413	36.116	37.107	74.636		848.940	8.79%
5/25/2016	WEDNESDAY	73.7	1.144	26.210	28.772	56.126		757.670	7.41%
5/26/2016	THURSDAY	76.8	1.396	35.900	45.351	82.647		784.110	10.54%

TTR										
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
5/27/2016	FRIDAY	71.8	1.398	51.111	33.203	85.712		867.330	9.88%
6/11/2016	SATURDAY	82.0	0.000	0.322	0.263	0.585	576.300	516.040	0.11%
6/12/2016	SUNDAY	77.0	0.000	0.327	0.263	0.590		473.910	0.12%
6/13/2016	MONDAY	77.4	0.000	0.327	0.262	0.589		446.370	0.13%
6/14/2016	TUESDAY	81.3	1.926	34.798	23.876	60.600		931.380	6.51%
6/15/2016	WEDNESDAY	82.3	6.623	77.835	98.740	183.198		1611.150	11.37%
6/16/2016	THURSDAY	76.6	6.278	66.710	80.633	153.622		1430.250	10.74%
6/17/2016	FRIDAY	76.1	6.166	96.627	74.323	177.117		1570.670	11.28%
6/18/2016	SATURDAY	76.5	7.041	75.864	62.420	145.325	638.530	1364.310	10.65%
6/19/2016	SUNDAY	78.7	0.000	0.344	0.275	0.619		571.900	0.11%
6/20/2016	MONDAY	81.5	5.920	43.351	42.136	91.407		1164.280	7.85%
6/21/2016	TUESDAY	77.3	2.620	61.365	71.065	135.051		925.360	14.59%
6/22/2016	WEDNESDAY	76.5	0.978	48.058	42.310	91.346		933.580	9.78%
6/23/2016	THURSDAY	75.3	1.640	45.441	45.683	92.764		1037.880	8.94%
6/24/2016	FRIDAY	74.3	1.483	38.553	41.983	82.019		911.060	9.00%
7/9/2016	SATURDAY	73.3	6.386	90.703	81.288	178.376	710.113	1304.510	13.67%
7/10/2016	SUNDAY	71.6	6.645	80.877	76.940	164.462		1212.410	13.56%
7/11/2016	MONDAY	81.4	1.361	26.095	42.203	69.659		932.720	7.47%
7/12/2016	TUESDAY	76.2	1.296	36.668	28.295	66.259		965.030	6.87%
7/13/2016	WEDNESDAY	76.0	0.833	38.440	26.616	65.889			
7/14/2016	THURSDAY	76.1	1.575	44.565	45.307	91.447			
7/15/2016	FRIDAY	68.5	1.504	36.423	36.093	74.020			
7/16/2016	SATURDAY	71.3	0.000	0.000	0.000	0.000			
7/17/2016	SUNDAY	75.1	0.000	0.000	0.000	0.000			
7/18/2016	MONDAY	78.1	0.000	0.000	0.000	0.000			
7/19/2016	TUESDAY	74.4	0.000	0.000	0.000	0.000			
7/20/2016	WEDNESDAY	76.4	0.000	0.000	0.000	0.000			
7/21/2016	THURSDAY	84.6	0.000	0.000	0.000	0.000			

TTR									
Date		Average Daily Temp.	RTU-1 Total	RTU-3 Total	RTU-4 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	kWh	%
7/22/2016	FRIDAY	78.3	0.000	0.000	0.000	0.000			
8/6/2016	SATURDAY	71.4	5.594	58.804	65.207	129.605	776.702		
8/7/2016	SUNDAY	70.9	5.763	74.253	66.795	146.811			
8/8/2016	MONDAY	74.2	2.426	37.527	67.298	107.251			
8/9/2016	TUESDAY	75.9	0.883	36.783	52.918	90.585			
8/10/2016	WEDNESDAY	79.5	0.838	29.667	43.594	74.099			
8/11/2016	THURSDAY	79.9	1.790	62.493	59.668	123.952			
8/12/2016	FRIDAY	76.2	1.996	36.135	66.269	104.400			
8/13/2016	SATURDAY	75.3	0.000	0.000	0.000	0.000			
8/14/2016	SUNDAY	72.9	0.000	0.000	0.000	0.000			
8/15/2016	MONDAY	72.4	0.000	0.000	0.000	0.000			
8/16/2016	TUESDAY	75.5	0.000	0.000	0.000	0.000			
8/17/2016	WEDNESDAY	77.5	0.000	0.000	0.000	0.000			
8/18/2016	THURSDAY	80.2	0.000	0.000	0.000	0.000			
8/19/2016	FRIDAY	79.1	0.000	0.000	0.000	0.000			
9/3/2016	SATURDAY	66.1	0.003	0.366	0.271	0.641	327.760	495.025	0.13%
9/4/2016	SUNDAY	68.1	0.002	0.342	0.270	0.614		577.481	0.11%
9/5/2016	MONDAY	75.2	0.001	0.334	0.267	0.601		497.628	0.12%
9/6/2016	TUESDAY	81.5	2.893	42.833	39.087	84.813		1046.890	8.10%
9/7/2016	WEDNESDAY	78.7	2.876	44.348	36.724	83.947		1008.549	8.32%
9/8/2016	THURSDAY	77.0	2.475	39.881	47.215	89.572		991.617	9.03%
9/9/2016	FRIDAY	74.7	2.417	43.498	21.657	67.573		833.800	8.10%
9/10/2016	SATURDAY	66.4	0.001	0.351	0.271	0.623	429.590	458.754	0.14%
9/11/2016	SUNDAY	64.9	0.005	0.343	0.267	0.614		458.454	0.13%
9/12/2016	MONDAY	68.0	2.873	35.934	30.412	69.219		792.159	8.74%
9/13/2016	TUESDAY	69.3	2.569	44.220	33.175	79.964		870.699	9.18%
9/14/2016	WEDNESDAY	67.2	2.349	36.751	31.562	70.662		746.048	9.47%
9/15/2016	THURSDAY	71.8	1.824	32.715	40.715	75.254		851.879	8.83%

TTR									
Date		**Average Daily Temp.**	**RTU-1 Total**	**RTU-3 Total**	**RTU-4 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**kWh**	**%**
9/16/2016	FRIDAY	74.2	6.070	60.647	66.537	133.254		1325.245	10.06%
10/1/2016	SATURDAY	62.5	0.002	0.357	0.268	0.627	464.568		
10/2/2016	SUNDAY	63.1	0.002	0.344	0.270	0.616			
10/3/2016	MONDAY	61.6	2.203	39.353	35.387	76.944			
10/4/2016	TUESDAY	68.7	2.407	40.004	30.431	72.843			
10/5/2016	WEDNESDAY	68.8	2.369	35.520	30.879	68.768			
10/6/2016	THURSDAY	66.3	4.679	59.819	45.953	110.452			
10/7/2016	FRIDAY	55.6	3.504	81.751	49.063	134.319			
10/8/2016	SATURDAY	55.0	0.009	0.361	0.278	0.649	423.026		
10/9/2016	SUNDAY	57.0	0.010	0.355	0.276	0.642			
10/10/2016	MONDAY	58.5	0.007	0.354	0.272	0.634			
10/11/2016	TUESDAY	66.0	2.143	47.656	32.524	82.323			
10/12/2016	WEDNESDAY	56.1	2.216	46.699	36.982	85.897			
10/13/2016	THURSDAY	44.6	3.343	94.948	70.245	168.536			
10/14/2016	FRIDAY	51.5	0.000	0.000	0.000	0.000			

Site #3:

FIXED STATIC PRESSURE										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
8/2/2015	Sunday	79.27	44.621	46.274	0.000	0.000	46.274	304.531	1566.0	2.95%
8/3/2015	Monday	69.56	43.408	44.563	0.000	0.000	44.563		1451.0	3.07%
8/4/2015	Tuesday	68.02	43.024	44.084	0.000	0.000	44.084		1806.0	2.44%
8/5/2015	Wednesday	67.67	42.629	43.613	0.000	0.000	43.613			
8/6/2015	Thursday	70.33	42.151	43.056	0.000	0.000	43.056			
8/7/2015	Friday	73.68	41.242	42.139	0.000	0.000	42.139			
8/8/2015	Saturday	71.51	40.365	40.803	0.000	0.000	40.803			
8/9/2015	Sunday	72.22	40.832	41.400	0.000	0.000	41.400	289.837		
8/10/2015	Monday	72.82	40.650	41.155	0.000	0.000	41.155			
8/11/2015	Tuesday	69.94	38.680	38.766	0.000	0.000	38.766		1747.0	2.22%
8/12/2015	Wednesday	68.79	40.444	40.845	0.000	0.000	40.845		1842.0	2.22%
8/13/2015	Thursday	74.43	39.266	39.449	0.000	0.000	39.449		2140.0	1.84%
8/14/2015	Friday	78.72	44.876	46.384	0.000	0.000	46.384			
8/15/2015	Saturday	75.81	41.288	41.837	0.000	0.000	41.837			
8/30/2015	Sunday	63.26	25.375	24.190	27.449	27.487	51.677	345.565	1242.0	4.16%
8/31/2015	Monday	66.28	27.975	26.847	29.595	29.599	56.446		1443.0	3.91%
9/1/2015	Tuesday	77.32	34.814	34.470	20.885	20.844	55.314		2058.0	2.69%
9/2/2015	Wednesday	76.96	40.487	40.900	0.000	0.000	40.900			
9/3/2015	Thursday	79.15	44.296	45.722	0.000	0.000	45.722			
9/4/2015	Friday	79.13	46.414	48.270	0.000	0.000	48.270			
9/5/2015	Saturday	80.87	45.580	47.235	0.000	0.000	47.235			
9/6/2015	Sunday	80.70	48.169	50.453	0.000	0.000	50.453	273.566		
9/7/2015	Monday	72.96	42.170	42.937	0.000	0.000	42.937			
9/8/2015	Tuesday	71.65	39.874	40.201	0.000	0.000	40.201		2124.0	1.89%
9/9/2015	Wednesday	67.61	35.001	34.575	0.000	0.000	34.575		1974.0	1.75%
9/10/2015	Thursday	68.39	34.004	33.499	0.000	0.000	33.499		1761.0	1.90%
9/11/2015	Friday	56.44	38.755	38.923	0.000	0.000	38.923			
9/12/2015	Saturday	55.27	33.607	32.978	0.000	0.000	32.978			

FIXED STATIC PRESSURE										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
9/27/2015	Sunday	67.59	34.315	33.899	0.000	0.000	33.899	255.620	1098.0	3.09%
9/28/2015	Monday	70.53	35.832	35.619	0.000	0.000	35.619		1339.0	2.66%
9/29/2015	Tuesday	61.13	34.045	33.553	0.000	0.000	33.553		1619.0	2.07%
9/30/2015	Wednesday	50.89	35.861	35.672	0.000	0.000	35.672			
10/1/2015	Thursday	50.09	35.925	35.616	0.000	0.000	35.616			
10/2/2015	Friday	50.32	41.687	42.519	0.000	0.000	42.519			
10/3/2015	Saturday	48.85	38.677	38.743	0.000	0.000	38.743			
10/4/2015	Sunday	48.19	39.888	40.305	0.000	0.000	40.305	261.172	1141.0	3.53%
10/5/2015	Monday	54.73	37.821	37.940	0.000	0.000	37.940		1154.0	3.29%
10/6/2015	Tuesday	55.07	37.306	37.272	0.000	0.000	37.272		1483.0	2.51%
10/7/2015	Wednesday	58.67	35.903	35.602	0.000	0.000	35.602		1646.0	2.16%
10/8/2015	Thursday	63.91	37.105	37.188	0.000	0.000	37.188		1571.0	2.37%
10/9/2015	Friday	53.98	37.117	37.057	0.000	0.000	37.057			
10/10/2015	Saturday	53.78	36.071	35.809	0.000	0.000	35.809			
10/25/2015	Sunday	40.00	36.722	36.593	0.000	0.000	36.593	261.444	1207.0	3.03%
10/26/2015	Monday	49.21	38.029	38.069	0.000	0.000	38.069		1127.0	3.38%
10/27/2015	Tuesday	48.80	39.991	40.449	0.000	0.000	40.449			
10/28/2015	Wednesday	45.11	37.571	37.644	0.000	0.000	37.644			
10/29/2015	Thursday	42.41	36.824	36.770	0.000	0.000	36.770			
10/30/2015	Friday	46.70	36.033	35.799	0.000	0.000	35.799			
10/31/2015	Saturday	47.37	37.586	36.120	0.000	0.000	36.120		1089.0	3.32%
11/1/2015	Sunday	53.12	35.409	35.225	0.000	0.000	35.225	252.124	1104.0	3.19%
11/2/2015	Monday	59.75	32.794	32.199	0.000	0.000	32.199		1049.0	3.07%
11/3/2015	Tuesday	55.98	38.108	38.245	0.000	0.000	38.245		1406.0	2.72%
11/4/2015	Wednesday	56.52	38.802	39.020	0.000	0.000	39.020		1338.0	2.92%
11/5/2015	Thursday	58.34	36.785	36.703	0.000	0.000	36.703			
11/6/2015	Friday	45.13	37.356	37.339	0.000	0.000	37.339			
11/7/2015	Saturday	39.54	34.000	33.392	0.000	0.000	33.392			

FIXED STATIC PRESSURE										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
11/22/2015	Sunday	21.98	33.561	33.005	0.000	0.000	33.005	278.354	1279.0	2.58%
11/23/2015	Monday	26.20	34.649	34.150	0.000	0.000	34.150		1386.0	2.46%
11/24/2015	Tuesday	30.50	43.128	44.510	0.000	0.000	44.510		1802.0	2.47%
11/25/2015	Wednesday	45.64	41.058	41.582	0.000	0.000	41.582		1648.0	2.52%
11/26/2015	Thursday	41.56	40.939	41.407	0.000	0.000	41.407		1275.0	3.25%
11/27/2015	Friday	28.95	38.286	38.302	0.000	0.000	38.302		1364.0	2.81%
11/28/2015	Saturday	25.11	44.072	45.399	0.000	0.000	45.399		1312.0	3.46%
11/29/2015	Sunday	31.07	45.572	47.239	0.000	0.000	47.239	282.322		
11/30/2015	Monday	34.87	0.000	0.000	0.000	0.000	0.000			
12/1/2015	Tuesday	32.01	37.686	37.761	0.000	0.000	37.761			
12/2/2015	Wednesday	30.23	40.583	40.973	0.000	0.000	40.973			
12/3/2015	Thursday	32.40	41.447	42.016	0.000	0.000	42.016		2081.0	2.02%
12/4/2015	Friday	35.41	38.774	38.834	0.000	0.000	38.834		2167.0	1.79%
12/5/2015	Saturday	39.21	36.008	35.601	0.000	0.000	35.601		1987.0	1.79%
12/20/2015	Sunday	41.60	39.679	40.138	0.000	0.000	40.138	279.100	1308.0	3.07%
12/21/2015	Monday	36.28	39.995	40.419	0.000	0.000	40.419		1395.0	2.90%
12/22/2015	Tuesday	32.43	38.410	38.641	0.000	0.000	38.641		1732.0	2.23%
12/23/2015	Wednesday	40.51	40.882	41.623	0.000	0.000	41.623		1715.0	2.43%
12/24/2015	Thursday	29.56	38.944	39.221	0.000	0.000	39.221		1398.0	2.81%
12/25/2015	Friday	26.62	37.401	37.293	0.000	0.000	37.293		1234.0	3.02%
12/26/2015	Saturday	32.93	41.170	41.765	0.000	0.000	41.765		1328.0	3.14%
12/27/2015	Sunday	28.37	41.027	41.627	0.000	0.000	41.627	285.290	1426.0	2.92%
12/28/2015	Monday	24.71	39.220	39.476	0.000	0.000	39.476		1547.0	2.55%
12/29/2015	Tuesday	23.70	40.660	41.132	0.000	0.000	41.132		2032.0	2.02%
12/30/2015	Wednesday	23.08	38.740	38.802	0.000	0.000	38.802		1876.0	2.07%
12/31/2015	Thursday	17.33	39.919	40.207	0.000	0.000	40.207		1813.0	2.22%
1/1/2016	Friday	23.08	41.619	42.308	0.000	0.000	42.308		1647.0	2.57%
1/2/2016	Saturday	18.40	41.195	41.738	0.000	0.000	41.738		1641.0	2.54%
1/17/2016	Sunday	-8.10	3.079	3.099	0.294	0.294	3.393	278.432	1402.0	

FIXED STATIC PRESSURE										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
1/18/2016	Monday	-3.76	0.087	0.087	0.246	0.247	0.333		1389.0	
1/19/2016	Tuesday	3.92	0.106	0.107	0.247	0.247	0.354		1999.0	
1/20/2016	Wednesday	13.59	21.880	21.864	8.853	8.853	30.717		2543.0	1.21%
1/21/2016	Thursday	16.94	39.582	40.033	1.573	1.572	41.605		2711.0	1.53%
1/22/2016	Friday	21.12	41.885	42.548	0.000	0.000	42.548		2323.0	1.83%
1/23/2016	Saturday	22.36	42.710	43.491	0.000	0.000	43.491		2102.0	2.07%
1/24/2016	Sunday	26.42	42.304	43.199	0.000	0.000	43.199	299.194	1971.0	2.19%
1/25/2016	Monday	27.67	42.519	43.438	0.000	0.000	43.438		1696.0	2.56%
1/26/2016	Tuesday	24.80	42.968	43.924	0.000	0.000	43.924		2205.0	1.99%
1/27/2016	Wednesday	27.35	40.767	41.305	0.000	0.000	41.305		2281.0	1.81%
1/28/2016	Thursday	32.03	40.961	41.489	0.000	0.000	41.489		2198.0	1.89%
1/29/2016	Friday	26.64	41.869	42.564	0.000	0.000	42.564		2032.0	2.09%
1/30/2016	Saturday	30.26	42.471	43.275	0.000	0.000	43.275		1460.0	2.96%
2/14/2016	Sunday	16.72	50.271	53.308	0.000	0.000	53.308	290.941	1521.0	3.50%
2/15/2016	Monday	24.28	44.525	46.111	0.000	0.000	46.111		1420.0	3.25%
2/16/2016	Tuesday	30.27	40.784	41.351	0.000	0.000	41.351		2053.0	2.01%
2/17/2016	Wednesday	27.63	33.747	33.184	0.000	0.000	33.184		2044.0	1.62%
2/18/2016	Thursday	35.07	37.436	37.379	0.000	0.000	37.379		2189.0	1.71%
2/19/2016	Friday	42.61	40.729	41.525	0.000	0.000	41.525		1719.0	2.42%
2/20/2016	Saturday	39.51	38.025	38.084	0.000	0.000	38.084		1285.0	2.96%
2/21/2016	Sunday	34.23	37.210	37.174	0.000	0.000	37.174	278.894	1335.0	2.78%
2/22/2016	Monday	34.54	37.758	37.790	5.465	5.465	43.255		1579.0	2.74%
2/23/2016	Tuesday	36.55	39.493	39.720	0.000	0.000	39.720		1883.0	2.11%
2/24/2016	Wednesday	34.82	38.030	38.103	0.000	0.000	38.103		2066.0	1.84%
2/25/2016	Thursday	32.04	39.286	39.521	0.000	0.000	39.521		2099.0	1.88%
2/26/2016	Friday	33.65	42.498	43.186	0.000	0.000	43.186		1926.0	2.24%
2/27/2016	Saturday	46.08	37.935	37.936	0.000	0.000	37.936		1319.0	2.88%
3/13/2016	Sunday	48.59	30.522	28.270	32.414	31.077	59.347	293.304	1468.0	4.04%
3/14/2016	Monday	51.86	32.347	31.583	9.283	9.239	40.822		1276.0	3.20%

FIXED STATIC PRESSURE										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
3/15/2016	Tuesday	51.73	36.087	35.845	0.000	0.000	35.845		1676.0	2.14%
3/16/2016	Wednesday	47.43	35.135	34.820	0.000	0.000	34.820		1860.0	1.87%
3/17/2016	Thursday	42.60	37.711	37.732	0.000	0.000	37.732		1877.0	2.01%
3/18/2016	Friday	34.07	42.103	42.809	0.000	0.000	42.809		1843.0	2.32%
3/19/2016	Saturday	34.58	41.375	41.928	0.000	0.000	41.928		1385.0	3.03%
3/20/2016	Sunday	36.77	41.462	42.113	0.000	0.000	42.113	289.415	1430.0	2.94%
3/21/2016	Monday	40.05	39.928	40.276	0.000	0.000	40.276		1478.0	2.73%
3/22/2016	Tuesday	50.63	37.629	37.738	0.000	0.000	37.738		1606.0	2.35%
3/23/2016	Wednesday	35.96	39.957	40.284	0.000	0.000	40.284		1705.0	2.36%
3/24/2016	Thursday	32.05	42.805	43.634	0.000	0.000	43.634		2223.0	1.96%
3/25/2016	Friday	37.56	41.802	42.492	0.000	0.000	42.492		1747.0	2.43%
3/26/2016	Saturday	44.51	42.114	42.878	0.000	0.000	42.878		1244.0	3.45%
4/10/2016	Sunday	49.54	40.059	40.510	0.000	0.000	40.510	240.808	1207.0	3.36%
4/11/2016	Monday	40.21	39.767	40.010	0.000	0.000	40.010		1518.0	2.64%
4/12/2016	Tuesday	40.17	38.053	37.999	0.000	0.000	37.999		1663.0	2.28%
4/13/2016	Wednesday	53.47	34.750	34.303	0.000	0.000	34.303		1701.0	2.02%
4/14/2016	Thursday	56.83	30.845	29.925	0.000	0.000	29.925		1605.0	1.86%
4/15/2016	Friday	61.29	30.145	29.215	0.000	0.000	29.215		1461.0	2.00%
4/16/2016	Saturday	65.82	29.833	28.846	0.000	0.000	28.846		1056.0	2.73%
4/17/2016	Sunday	65.88	32.839	32.121	0.000	0.000	32.121	223.538	1050.0	3.06%
4/18/2016	Monday	64.88	32.214	31.476	0.000	0.000	31.476		1167.0	2.70%
4/19/2016	Tuesday	56.71	33.644	32.938	0.000	0.000	32.938		1502.0	2.19%
4/20/2016	Wednesday	54.40	32.780	32.106	0.000	0.000	32.106		1730.0	1.86%
4/21/2016	Thursday	55.36	31.606	30.828	0.000	0.000	30.828		1678.0	1.84%
4/22/2016	Friday	52.81	33.114	32.406	0.000	0.000	32.406		1547.0	2.09%
4/23/2016	Saturday	52.39	32.463	31.665	0.000	0.000	31.665		1128.0	2.81%
5/8/2016	Sunday		0.000		0.000		0.000	0.000	1019.0	
5/9/2016	Monday		0.000		0.000		0.000		1144.0	
5/10/2016	Tuesday		0.000		0.000		0.000		1479.0	

FIXED STATIC PRESSURE										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
5/11/2016	Wednesday		0.000		0.000		0.000		1505.0	
5/12/2016	Thursday		0.000		0.000		0.000		1696.0	
5/13/2016	Friday		0.000		0.000		0.000		1805.0	
5/14/2016	Saturday		0.000		0.000		0.000		1745.0	
5/15/2016	Sunday	50.52	35.715	35.377	0.216	0.216	35.592	232.382	1626.0	2.19%
5/16/2016	Monday	58.48	33.390	32.735	0.218	0.218	32.953		1164.0	2.83%
5/17/2016	Tuesday	56.05	34.861	34.356	0.201	0.201	34.557		1504.0	2.30%
5/18/2016	Wednesday	54.63	33.337	32.724	0.189	0.189	32.913		1748.0	1.88%
5/19/2016	Thursday	58.56	33.285	32.729	0.192	0.191	32.920		1702.0	1.93%
5/20/2016	Friday	62.10	32.364	31.640	0.210	0.211	31.851		1406.0	2.27%
5/21/2016	Saturday	63.74	32.141	31.411	0.186	0.185	31.595		1454.0	2.17%
6/5/2016	Sunday	69.99	39.722	40.518	0.201	0.201	40.719	292.856	1410.0	2.89%
6/6/2016	Monday	66.30	38.816	39.570	0.178	0.178	39.747		1217.0	3.27%
6/7/2016	Tuesday	62.40	38.211	38.589	0.202	0.203	38.792		1388.0	2.79%
6/8/2016	Wednesday	66.60	34.924	34.810	0.205	0.205	35.016		1457.0	2.40%
6/9/2016	Thursday	71.04	40.351	40.866	0.202	0.201	41.067		1613.0	2.55%
6/10/2016	Friday	78.75	43.369	43.759	0.203	0.203	43.962		1923.0	2.29%
6/11/2016	Saturday	76.21	52.877	53.352	0.201	0.201	53.553		1753.0	3.05%
6/12/2016	Sunday	74.79	46.348	48.186	0.196	0.197	48.383	361.564	1607.0	3.01%
6/13/2016	Monday	75.98	44.044	45.341	0.205	0.204	45.545		1507.0	3.02%
6/14/2016	Tuesday	73.78	46.438	48.392	0.204	0.205	48.597		1824.0	2.66%
6/15/2016	Wednesday	73.56	52.794	56.112	0.204	0.204	56.316		1842.0	3.06%
6/16/2016	Thursday	72.74	49.209	51.956	0.203	0.203	52.159		1836.0	2.84%
6/17/2016	Friday	71.47	52.855	56.174	0.201	0.201	56.375		1978.0	2.85%
6/18/2016	Saturday	75.90	50.776	53.985	0.202	0.203	54.188		1812.0	2.99%
7/3/2016	Sunday	65.09	38.927	39.636	0.202	0.202	39.838	315.593	1234.0	3.23%
7/4/2016	Monday	66.99	40.065	40.786	0.197	0.198	40.984		1228.0	3.34%
7/5/2016	Tuesday	77.36	40.077	40.634	0.205	0.204	40.838		2152.0	1.90%
7/6/2016	Wednesday	75.28	43.660	45.056	0.204	0.204	45.260		2182.0	2.07%

FIXED STATIC PRESSURE										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
7/7/2016	Thursday	75.31	45.220	46.850	0.207	0.206	47.057		2304.0	2.04%
7/8/2016	Friday	73.97	45.759	47.549	0.205	0.205	47.755		2069.0	2.31%
7/9/2016	Saturday	71.96	50.590	53.660	0.201	0.201	53.861		2042.0	2.64%
7/10/2016	Sunday	69.15	45.830	47.705	0.202	0.202	47.907	354.216	2000.0	2.40%
7/11/2016	Monday	79.79	51.613	54.444	0.203	0.203	54.646		1907.0	2.87%
7/12/2016	Tuesday	72.59	48.356	50.811	0.204	0.205	51.016		2257.0	2.26%
7/13/2016	Wednesday	76.80	50.171	52.703	0.208	0.206	52.909			
7/14/2016	Thursday	73.00	48.589	51.082	0.201	0.201	51.283			
7/15/2016	Friday	66.50	46.659	48.737	0.205	0.205	48.942			
7/16/2016	Saturday	68.53	45.532	47.311	0.201	0.201	47.512			
7/31/2016	Sunday	72.80	43.172	44.279	0.204	0.204	44.483	348.767	1520.0	2.93%
8/1/2016	Monday	75.08	43.798	44.973	0.204	0.204	45.177		1678.0	2.69%
8/2/2016	Tuesday	75.24	44.114	45.318	0.204	0.204	45.522		2165.0	2.10%
8/3/2016	Wednesday	73.16	53.521	56.635	0.203	0.203	56.838		2276.0	2.50%
8/4/2016	Thursday	77.06	51.719	54.787	0.204	0.204	54.991		2521.0	2.18%
8/5/2016	Friday	70.48	49.336	51.993	0.194	0.194	52.186		2242.0	2.33%
8/6/2016	Saturday	69.05	47.202	49.366	0.203	0.204	49.570		1959.0	2.53%
8/7/2016	Sunday	66.50	49.323	52.045	0.195	0.195	52.240	368.239		
8/8/2016	Monday	72.00	47.077	49.179	0.202	0.202	49.381			
8/9/2016	Tuesday	75.15	49.223	51.764	0.203	0.203	51.967			
8/10/2016	Wednesday	77.26	53.622	56.672	0.202	0.202	56.873			
8/11/2016	Thursday	75.93	57.950	62.079	0.203	0.204	62.283			
8/12/2016	Friday	72.62	46.575	48.463	0.207	0.205	48.669			
8/13/2016	Saturday	71.91	45.141	46.622	0.203	0.203	46.825			
8/28/2016	Sunday	69.08	48.995	51.611	0.201	0.202	51.813	301.983		
8/29/2016	Monday	72.62	42.799	43.648	0.205	0.205	43.853			
8/30/2016	Tuesday	72.27	42.330	43.082	0.205	0.204	43.286			
8/31/2016	Wednesday	67.07	42.603	43.715	0.209	0.209	43.924			
9/1/2016	Thursday	64.11	39.185	39.721	0.216	0.217	39.938			

FIXED STATIC PRESSURE										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
9/2/2016	Friday	63.65	38.976	39.581	0.185	0.183	39.764			
9/3/2016	Saturday	64.51	38.785	39.231	0.173	0.174	39.405			
9/4/2016	Sunday	69.80	40.244	41.220	0.166	0.166	41.387	299.645		
9/5/2016	Monday	76.83	40.048	40.564	0.196	0.196	40.760			
9/6/2016	Tuesday	81.17	39.206	39.430	0.211	0.211	39.641			
9/7/2016	Wednesday	73.17	42.020	42.815	0.205	0.205	43.020			
9/8/2016	Thursday	71.55	44.180	45.601	0.205	0.205	45.806			
9/9/2016	Friday	67.18	43.462	44.733	0.203	0.203	44.936			
9/10/2016	Saturday	62.58	42.619	43.892	0.203	0.203	44.095			
9/25/2016	Sunday	67.60	27.160	26.011	28.737	28.803	54.814	268.328		
9/26/2016	Monday	58.69	35.479	35.047	0.993	0.944	35.991			
9/27/2016	Tuesday	58.25	34.733	34.256	0.192	0.191	34.448			
9/28/2016	Wednesday	54.61	36.034	35.666	0.200	0.200	35.866			
9/29/2016	Thursday	59.50	36.925	36.642	0.212	0.212	36.854			
9/30/2016	Friday	58.17	37.011	36.818	0.202	0.202	37.020			
10/1/2016	Saturday	60.71	33.823	33.155	0.181	0.181	33.336			
10/2/2016	Sunday	56.70	34.265	33.736	0.232	0.232	33.968	246.762		
10/3/2016	Monday	60.27	35.101	34.665	0.201	0.202	34.866			
10/4/2016	Tuesday	65.90	33.457	32.946	0.212	0.211	33.157			
10/5/2016	Wednesday	63.77	37.348	37.517	0.200	0.200	37.716			
10/6/2016	Thursday	64.16	34.584	34.229	0.205	0.205	34.434			
10/7/2016	Friday	50.37	36.982	36.916	0.219	0.219	37.135			
10/8/2016	Saturday	51.52	35.665	35.261	0.225	0.225	35.485			

Site #3:

TTR Method										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
7/19/2015	Sunday	74.67	39.088	39.088	0.000	0.195	39.283	190.194		
7/20/2015	Monday	72.38	30.591	30.591	0.000	0.197	30.789			
7/21/2015	Tuesday	69.31	26.098	25.109	0.000	0.203	25.312			
7/22/2015	Wednesday	68.79	25.481	24.424	0.000	0.203	24.627			
7/23/2015	Thursday	71.86	28.164	27.149	0.000	0.198	27.348			
7/24/2015	Friday	71.30	19.154	18.138	0.000	0.195	18.333		1709.0	1.07%
7/25/2015	Saturday	77.17	25.347	24.301	0.000	0.202	24.503		1804.0	1.36%
7/26/2015	Sunday	75.54	25.081	23.833	0.000	0.198	24.031	190.194	1538.0	1.56%
7/27/2015	Monday	76.17	36.775	36.925	0.000	0.201	37.126			
7/28/2015	Tuesday	72.99	29.694	28.720	0.000	0.204	28.924			
7/29/2015	Wednesday	75.01	26.650	25.455	0.000	0.198	25.653			
7/30/2015	Thursday	74.83	31.002	30.119	0.000	0.196	30.315			
7/31/2015	Friday	74.33	31.946	31.096	0.000	0.203	31.299			
8/1/2015	Saturday	73.87	29.992	29.009	0.000	0.201	29.210			
8/16/2015	Sunday	76.95	25.220	23.987	0.000	0.201	24.188	151.709		
8/17/2015	Monday	72.15	24.973	23.743	0.000	0.200	23.942			
8/18/2015	Tuesday	67.15	19.426	18.310	0.000	0.204	18.515			
8/19/2015	Wednesday	60.43	25.084	23.968	0.000	0.198	24.166			
8/20/2015	Thursday	64.57	21.197	20.212	0.000	0.205	20.417		1769.0	1.15%
8/21/2015	Friday	69.89	19.842	18.887	0.000	0.200	19.087		1585.0	1.20%
8/22/2015	Saturday	71.39	21.978	21.192	0.000	0.202	21.394		1217.0	1.76%
8/23/2015	Sunday	64.81	19.097	18.218	0.000	0.183	18.402	153.042	1101.0	1.67%
8/24/2015	Monday	60.75	12.282	11.672	3.874	3.874	15.546			
8/25/2015	Tuesday	61.36	10.848	10.376	10.665	10.665	21.041			
8/26/2015	Wednesday	58.66	11.432	10.910	11.238	11.238	22.148			
8/27/2015	Thursday	63.10	11.482	10.953	11.359	11.359	22.312			
8/28/2015	Friday	62.96	14.943	14.155	14.858	14.858	29.013			

TTR Method										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
8/29/2015	Saturday	66.83	12.691	12.059	12.520	12.520	24.579		1118.0	2.20%
9/13/2015	Sunday	58.98	18.091	17.096	0.000	0.193	17.289	133.685		
9/14/2015	Monday	69.28	16.703	15.842	0.000	0.200	16.041			
9/15/2015	Tuesday	73.60	17.504	16.609	0.000	0.191	16.800			
9/16/2015	Wednesday	75.28	21.611	20.534	0.000	0.202	20.736			
9/17/2015	Thursday	72.54	22.496	21.367	0.000	0.197	21.564			
9/18/2015	Friday	61.95	23.143	22.040	0.000	0.210	22.250			
9/19/2015	Saturday	57.87	19.938	18.782	0.000	0.223	19.004		1781.0	1.07%
9/20/2015	Sunday	59.19	19.451	18.391	0.000	0.176	18.568	137.899		
9/21/2015	Monday	63.86	20.767	19.620	0.000	0.190	19.810			
9/22/2015	Tuesday	69.88	19.401	18.478	0.000	0.202	18.679			
9/23/2015	Wednesday	70.46	20.674	19.821	0.000	0.205	20.026			
9/24/2015	Thursday	69.50	20.227	19.311	0.000	0.204	19.515			
9/25/2015	Friday	67.30	22.433	21.508	0.000	0.202	21.710		1404.0	1.55%
9/26/2015	Saturday	65.79	20.374	19.392	0.000	0.198	19.590		1070.0	1.83%
10/11/2015	Sunday	67.29	18.193	17.161	0.000	0.254	17.414	158.706		
10/12/2015	Monday	62.16	20.017	18.939	0.000	0.242	19.181			
10/13/2015	Tuesday	51.18	24.965	23.708	0.000	0.249	23.957		1498.0	1.60%
10/14/2015	Wednesday	50.88	22.807	21.571	0.000	0.231	21.801		1645.0	1.33%
10/15/2015	Thursday	55.39	26.624	25.524	0.000	0.278	25.802		1598.0	1.61%
10/16/2015	Friday	41.43	26.651	25.360	0.000	0.250	25.610		1588.0	1.61%
10/17/2015	Saturday	38.97	25.988	24.697	0.000	0.242	24.939			
10/18/2015	Sunday	47.30	22.266	21.069	0.000	0.280	21.349	142.176		
10/19/2015	Monday	62.65	20.751	19.638	0.000	0.257	19.896			
10/20/2015	Tuesday	61.45	17.422	16.409	0.000	0.224	16.633			
10/21/2015	Wednesday	56.38	19.691	18.588	0.000	0.219	18.807			
10/22/2015	Thursday	50.36	23.192	21.949	0.000	0.227	22.176			
10/23/2015	Friday	55.20	23.386	22.207	0.000	0.201	22.408			
10/24/2015	Saturday	53.72	21.826	20.672	0.000	0.235	20.907		1466.0	1.43%

TTR Method										
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
11/8/2015	Sunday	43.57	21.897	20.744	0.000	0.212	20.956	146.297		
11/9/2015	Monday	43.10	23.130	21.877	0.000	0.221	22.099		1234.0	1.79%
11/10/2015	Tuesday	44.55	21.979	20.761	0.000	0.218	20.979		1497.0	1.40%
11/11/2015	Wednesday	51.50	20.142	18.988	0.000	0.223	19.210		1067.0	1.80%
11/12/2015	Thursday	41.96	20.864	19.671	0.000	0.246	19.917		1933.0	1.03%
11/13/2015	Friday	36.51	23.228	21.949	0.000	0.221	22.170		1622.0	1.37%
11/14/2015	Saturday	43.54	22.021	20.755	0.000	0.210	20.965		1074.0	1.95%
11/15/2015	Sunday	53.41	24.822	23.604	0.000	0.198	23.802	161.932	1039.0	2.29%
11/16/2015	Monday	50.56	22.558	21.303	0.000	0.241	21.544		1103.0	1.95%
11/17/2015	Tuesday	54.70	25.381	24.140	0.000	0.189	24.329		1446.0	1.68%
11/18/2015	Wednesday	50.20	26.157	25.015	0.000	0.221	25.236		1732.0	1.46%
11/19/2015	Thursday	36.10	22.431	21.171	0.000	0.270	21.441		1898.0	1.13%
11/20/2015	Friday	29.30	23.487	22.215	0.000	0.278	22.493		1594.0	1.41%
11/21/2015	Saturday	14.07	24.064	22.776	0.000	0.311	23.087		1290.0	1.79%
12/6/2015	Sunday	39.59	24.121	22.860	0.000	0.226	23.086	216.056	1606.0	1.44%
12/7/2015	Monday	38.93	23.480	22.348	9.851	9.886	32.234		1567.0	2.06%
12/8/2015	Tuesday	37.88	21.496	20.314	21.723	21.721	42.035		1814.0	2.32%
12/9/2015	Wednesday	40.84	21.282	20.102	21.452	21.445	41.547		1980.0	2.10%
12/10/2015	Thursday	46.79	22.926	21.693	7.338	7.311	29.005		1898.0	1.53%
12/11/2015	Friday	40.22	24.933	23.640	0.000	0.227	23.867		1591.0	1.50%
12/12/2015	Saturday	44.60	25.368	24.057	0.000	0.225	24.282		1193.0	2.04%
12/13/2015	Sunday	48.73	25.924	24.702	0.000	0.226	24.928	173.782	1191.0	2.09%
12/14/2015	Monday	42.48	25.487	24.233	0.000	0.250	24.483		1352.0	1.81%
12/15/2015	Tuesday	35.89	26.673	25.413	0.000	0.243	25.656		1852.0	1.39%
12/16/2015	Wednesday	36.84	25.952	24.717	0.000	0.247	24.964		1951.0	1.28%
12/17/2015	Thursday	29.06	25.467	24.224	0.000	0.280	24.504		2127.0	1.15%
12/18/2015	Friday	22.23	22.282	21.033	0.000	0.273	21.306		1464.0	1.46%
12/19/2015	Saturday	21.36	28.713	27.653	0.000	0.288	27.941		1360.0	2.05%

TTR Method										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
1/3/2016	Sunday	23.84	24.059	22.845	0.000	0.289	23.135	175.654	1441.0	1.61%
1/4/2016	Monday	21.58	20.557	19.455	0.000	0.264	19.719		1417.0	1.39%
1/5/2016	Tuesday	21.82	26.768	25.727	0.000	0.266	25.994		1856.0	1.40%
1/6/2016	Wednesday	29.52	31.808	30.953	0.000	0.235	31.188		1891.0	1.65%
1/7/2016	Thursday	33.19	22.523	21.336	0.000	0.230	21.566		1845.0	1.17%
1/8/2016	Friday	32.99	27.868	26.654	0.000	0.239	26.892		2053.0	1.31%
1/9/2016	Saturday	9.21	27.732	26.843	0.000	0.317	27.160		2188.0	1.24%
1/10/2016	Sunday	-3.54	40.282	40.528	0.000	0.325	40.853	214.281	2417.0	1.69%
1/11/2016	Monday	11.80	35.203	34.781	0.000	0.314	35.094		1897.0	1.85%
1/12/2016	Tuesday	3.31	27.565	26.282	0.000	0.317	26.599		2194.0	1.21%
1/13/2016	Wednesday	17.20	27.509	26.254	0.000	0.292	26.546		2546.0	1.04%
1/14/2016	Thursday	30.20	29.070	27.908	0.000	0.235	28.143		2016.0	1.40%
1/15/2016	Friday	22.64	30.185	29.062	0.000	0.317	29.379		1810.0	1.62%
1/16/2016	Saturday	5.56	28.619	27.341	0.000	0.325	27.666		1820.0	1.52%
1/31/2016	Sunday	33.20	28.281	27.177	0.000	0.241	27.418	186.486	1464.0	1.87%
2/1/2016	Monday	30.38	27.690	26.438	0.000	0.258	26.697		1656.0	1.61%
2/2/2016	Tuesday	32.53	28.911	27.713	0.000	0.283	27.995		1967.0	1.42%
2/3/2016	Wednesday	24.47	26.981	25.712	0.000	0.291	26.002		2024.0	1.28%
2/4/2016	Thursday	19.59	27.771	26.520	0.000	0.269	26.788		2352.0	1.14%
2/5/2016	Friday	14.68	28.357	27.063	0.000	0.242	27.305		2232.0	1.22%
2/6/2016	Saturday	29.23	25.321	24.025	0.000	0.255	24.280		2131.0	1.14%
2/7/2016	Sunday	34.68	24.133	22.913	0.000	0.315	23.228	189.731	1901.0	1.22%
2/8/2016	Monday	15.10	24.044	22.825	0.000	0.351	23.175		1646.0	1.41%
2/9/2016	Tuesday	11.49	27.894	26.654	0.000	0.301	26.955		2308.0	1.17%
2/10/2016	Wednesday	7.69	22.305	21.133	0.000	0.276	21.408		2200.0	0.97%
2/11/2016	Thursday	7.93	27.081	26.038	0.000	0.246	26.284		2136.0	1.23%
2/12/2016	Friday	12.50	32.376	31.624	0.000	0.346	31.970		1658.0	1.93%
2/13/2016	Saturday	3.75	36.832	36.400	0.000	0.310	36.710		1554.0	2.36%
2/28/2016	Sunday	43.32	26.202	25.017	0.000	0.266	25.283	289.650	1310.0	1.93%

TTR Method											
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
2/29/2016	Monday	31.54	23.805	22.533	12.618	12.652	35.185		1693.0	2.08%
3/1/2016	Tuesday	20.21	24.784	23.438	24.905	24.907	48.345		2414.0	2.00%
3/2/2016	Wednesday	19.41	23.588	22.274	23.696	23.694	45.969		2337.0	1.97%
3/3/2016	Thursday	28.84	21.807	20.587	21.956	21.957	42.544		2272.0	1.87%
3/4/2016	Friday	22.55	23.480	22.163	23.804	23.801	45.963		2227.0	2.06%
3/5/2016	Saturday	34.00	23.749	22.411	23.966	23.949	46.360		2275.0	2.04%
3/6/2016	Sunday	42.97	22.011	20.804	22.335	22.383	43.187	256.003	2024.0	2.13%
3/7/2016	Monday	56.94	18.664	17.612	19.019	19.009	36.620		1305.0	2.81%
3/8/2016	Tuesday	60.36	15.588	14.720	15.892	15.892	30.612		1619.0	1.89%
3/9/2016	Wednesday	43.04	14.817	14.008	15.007	15.011	29.019		1751.0	1.66%
3/10/2016	Thursday	35.94	21.066	19.854	21.466	21.472	41.326		1936.0	2.13%
3/11/2016	Friday	37.56	21.021	19.807	21.348	21.342	41.149		1992.0	2.07%
3/12/2016	Saturday	49.09	17.384	16.427	17.642	17.662	34.089		1611.0	2.12%
3/27/2016	Sunday	40.80	28.820	27.618	0.000	0.291	27.908	164.209	1258.0	2.22%
3/28/2016	Monday	42.90	24.356	23.101	0.000	0.253	23.354		1340.0	1.74%
3/29/2016	Tuesday	50.92	21.706	20.567	0.000	0.232	20.799		1652.0	1.26%
3/30/2016	Wednesday	52.03	19.987	18.862	0.000	0.227	19.089		1692.0	1.13%
3/31/2016	Thursday	44.36	23.552	22.285	0.000	0.241	22.526		1876.0	1.20%
4/1/2016	Friday	39.10	26.137	24.893	0.000	0.241	25.134		1715.0	1.47%
4/2/2016	Saturday	35.57	26.440	25.154	0.000	0.245	25.398		1373.0	1.85%
4/3/2016	Sunday	54.32	23.055	21.931	0.000	0.210	22.141	168.666	1594.0	1.39%
4/4/2016	Monday	36.98	23.414	22.160	0.000	0.217	22.377		1260.0	1.78%
4/5/2016	Tuesday	35.02	28.497	27.205	0.000	0.219	27.424		1959.0	1.40%
4/6/2016	Wednesday	43.29	23.056	21.876	0.000	0.233	22.109		1892.0	1.17%
4/7/2016	Thursday	40.51	24.210	22.932	0.000	0.228	23.160		1802.0	1.29%
4/8/2016	Friday	35.53	24.049	22.781	0.000	0.239	23.019		1671.0	1.38%
4/9/2016	Saturday	32.57	29.481	28.214	0.000	0.221	28.436		1520.0	1.87%
4/24/2016	Sunday	65.72	17.176	16.215	0.000	0.213	16.429	137.119	986.0	1.67%
4/25/2016	Monday	64.99	14.398	13.633	0.000	0.206	13.839		1337.0	1.04%

TTR Method										
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
4/26/2016	Tuesday	54.12	17.460	16.442	0.000	0.212	16.655		1575.0	1.06%
4/27/2016	Wednesday	44.49	21.324	20.125	0.000	0.218	20.343		1572.0	1.29%
4/28/2016	Thursday	46.12	19.106	18.023	0.000	0.211	18.234		1584.0	1.15%
4/29/2016	Friday	44.46	24.127	22.890	0.000	0.243	23.133		1654.0	1.40%
4/30/2016	Saturday	45.42	29.492	28.234	0.000	0.251	28.485		1388.0	2.05%
5/1/2016	Sunday	45.55	29.950	28.780	0.000	0.241	29.021	149.223	1328.0	2.19%
5/2/2016	Monday	48.45	21.960	20.861	0.000	0.246	21.107		1254.0	1.68%
5/3/2016	Tuesday	55.44	18.382	17.346	0.000	0.212	17.558		1591.0	1.10%
5/4/2016	Wednesday	55.05	19.276	18.179	0.000	0.205	18.384		1695.0	1.08%
5/5/2016	Thursday	53.53	20.718	19.550	0.000	0.203	19.753		1823.0	1.08%
5/6/2016	Friday	70.53	16.802	15.838	0.000	0.198	16.036		1499.0	1.07%
5/7/2016	Saturday	63.31	28.097	27.162	0.000	0.203	27.365		1055.0	2.59%
5/22/2016	Sunday	66.65	20.001	19.023	0.196	0.196	19.219	181.653	1429.0	1.34%
5/23/2016	Monday	71.84	22.181	21.219	8.050	8.068	29.288		1306.0	2.24%
5/24/2016	Tuesday	72.85	20.763	19.955	11.283	11.265	31.220		1825.0	1.71%
5/25/2016	Wednesday	70.37	27.322	26.402	0.209	0.208	26.609		1920.0	1.39%
5/26/2016	Thursday	68.01	23.099	22.091	0.205	0.206	22.298		1720.0	1.30%
5/27/2016	Friday	68.74	26.731	25.756	0.196	0.195	25.951		1284.0	2.02%
5/28/2016	Saturday	67.60	27.795	26.871	0.197	0.197	27.068		1212.0	2.23%
5/29/2016	Sunday	69.39	27.131	26.568	0.193	0.193	26.761	179.465	1229.0	2.18%
5/30/2016	Monday	65.15	27.910	27.316	0.196	0.196	27.512		1228.0	2.24%
5/31/2016	Tuesday	66.68	29.695	28.837	0.201	0.202	29.038		1729.0	1.68%
6/1/2016	Wednesday	64.71	27.809	26.720	0.200	0.198	26.919		1751.0	1.54%
6/2/2016	Thursday	65.03	21.386	20.350	0.204	0.204	20.554		1676.0	1.23%
6/3/2016	Friday	70.85	23.932	22.783	0.203	0.203	22.986		1928.0	1.19%
6/4/2016	Saturday	65.64	26.489	25.516	0.179	0.179	25.695		1912.0	1.34%
6/19/2016	Sunday	78.41	37.566	37.501	0.202	0.202	37.702	235.207	1701.0	2.22%
6/20/2016	Monday	77.75	40.702	41.087	0.207	0.206	41.294		1756.0	2.35%
6/21/2016	Tuesday	73.17	31.648	30.736	0.204	0.204	30.941		1888.0	1.64%

TTR Method											
Date		**Average Daily Temp.**	**RTU-1 Supply Fan**		**RTU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
6/22/2016	Wednesday	68.49	30.744	29.905	0.201	0.201	30.106		2179.0	1.38%
6/23/2016	Thursday	69.47	30.871	29.831	0.207	0.206	30.038		2129.0	1.41%
6/24/2016	Friday	70.93	30.237	29.210	0.179	0.179	29.389		1699.0	1.73%
6/25/2016	Saturday	80.47	35.644	35.550	0.188	0.188	35.738		1589.0	2.25%
6/26/2016	Sunday	77.89	36.321	35.949	0.197	0.197	36.146	206.595	1604.0	2.25%
6/27/2016	Monday	74.32	36.368	35.949	0.199	0.200	36.148		1541.0	2.35%
6/28/2016	Tuesday	66.13	32.027	31.692	0.207	0.205	31.897		1808.0	1.76%
6/29/2016	Wednesday	66.59	24.266	23.419	0.204	0.205	23.624		1869.0	1.26%
6/30/2016	Thursday	67.88	28.641	27.777	0.205	0.204	27.982		1636.0	1.71%
7/1/2016	Friday	64.35	24.201	23.411	0.205	0.205	23.616		1221.0	1.93%
7/2/2016	Saturday	65.98	27.912	26.996	0.186	0.186	27.182		1214.0	2.24%
7/17/2016	Sunday	71.20	29.168	28.282	0.202	0.202	28.484	293.921		
7/18/2016	Monday	75.14	31.422	30.510	0.207	0.206	30.716			
7/19/2016	Tuesday	71.09	27.594	26.400	0.200	0.201	26.600			
7/20/2016	Wednesday	78.02	38.140	38.887	0.200	0.198	39.085		2487.0	1.57%
7/21/2016	Thursday	84.87	52.580	55.612	0.199	0.198	55.810		2789.0	2.00%
7/22/2016	Friday	80.33	54.480	57.620	0.203	0.203	57.823		2385.0	2.42%
7/23/2016	Saturday	78.08	52.395	55.204	0.199	0.200	55.403		1772.0	3.13%
7/24/2016	Sunday	79.73	38.404	38.797	0.202	0.203	39.000	237.888	1687.0	2.31%
7/25/2016	Monday	74.59	34.399	33.636	0.201	0.200	33.836		1595.0	2.12%
7/26/2016	Tuesday	70.54	36.641	36.280	0.205	0.205	36.485		2121.0	1.72%
7/27/2016	Wednesday	73.67	37.624	37.398	0.189	0.189	37.587		2239.0	1.68%
7/28/2016	Thursday	69.37	35.252	34.562	0.205	0.205	34.768		2277.0	1.53%
7/29/2016	Friday	67.47	29.728	28.687	0.205	0.206	28.894		1602.0	1.80%
7/30/2016	Saturday	70.72	28.312	27.112	0.208	0.206	27.319		1421.0	1.92%
8/14/2016	Sunday	69.77	33.862	33.215	0.199	0.200	33.415	229.285		
8/15/2016	Monday	71.10	34.247	33.826	4.964	4.963	38.789			
8/16/2016	Tuesday	70.20	29.982	28.875	0.204	0.204	29.080			
8/17/2016	Wednesday	74.42	29.620	28.464	0.204	0.205	28.669			

TTR Method											
Date		Average Daily Temp.	RTU-1 Supply Fan		RTU-1 Exhaust Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
8/18/2016	Thursday	72.79	39.084	39.465	0.203	0.203	39.668			
8/19/2016	Friday	71.22	31.169	30.132	0.208	0.206	30.339			
8/20/2016	Saturday	66.04	30.055	29.130	0.196	0.196	29.326			
8/21/2016	Sunday	63.65	27.396	26.723	0.203	0.204	26.927	213.326		
8/22/2016	Monday	69.10	23.389	22.371	0.192	0.190	22.561			
8/23/2016	Tuesday	72.18	29.636	28.831	0.199	0.198	29.029			
8/24/2016	Wednesday	74.58	28.594	27.504	0.209	0.209	27.713		1527.0	1.81%
8/25/2016	Thursday	69.04	35.001	34.653	0.204	0.204	34.857		1955.0	1.78%
8/26/2016	Friday	61.27	34.205	34.359	0.202	0.203	34.562		2074.0	1.67%
8/27/2016	Saturday	66.20	37.618	37.475	0.203	0.202	37.677			
9/11/2016	Sunday	63.96	19.611	18.698	0.193	0.193	18.890	152.603		
9/12/2016	Monday	69.53	20.089	19.090	0.186	0.186	19.275			
9/13/2016	Tuesday	66.15	25.713	24.801	0.202	0.202	25.003			
9/14/2016	Wednesday	63.51	20.711	19.814	0.203	0.203	20.017			
9/15/2016	Thursday	66.02	20.709	19.675	0.202	0.202	19.877			
9/16/2016	Friday	66.00	25.775	24.767	0.202	0.202	24.968			
9/17/2016	Saturday	65.07	25.229	24.368	0.204	0.204	24.573			
9/18/2016	Sunday	67.21	18.684	17.756	0.180	0.180	17.936	160.934		
9/19/2016	Monday	69.65	25.546	24.532	0.207	0.208	24.740			
9/20/2016	Tuesday	65.46	17.671	16.828	0.207	0.205	17.033			
9/21/2016	Wednesday	75.96	21.653	20.456	0.201	0.201	20.656			
9/22/2016	Thursday	67.93	21.032	19.996	8.851	8.809	28.806			
9/23/2016	Friday	68.73	13.601	12.893	13.009	13.007	25.900			
9/24/2016	Saturday	69.64	13.507	12.833	13.007	13.030	25.863			

Site #4:

Fixed Static Pressure								
Date		Average Daily Temp.	AHU-1 Total	AHU-2 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	%
7/5/2015	Saturday		0.000	0.000	0.000	1538.71		
7/6/2015	Monday	71.52	62.507	162.943	225.451			
7/7/2015	Tuesday	60.71	80.685	141.726	222.410			
7/8/2015	Wednesday	62.22	88.654	164.743	253.397			
7/9/2015	Thursday	67.14	65.119	144.694	209.812			
7/10/2015	Friday	70.41	107.348	106.294	213.642			
7/11/2015	Saturday	73.55	126.856	80.142	206.999			
7/12/2015	Sunday	80.60	72.183	57.143	129.326	989.83		
7/13/2015	Monday	83.87	78.882	73.299	152.181			
7/14/2015	Tuesday	78.93	78.463	71.942	150.405			
7/15/2015	Wednesday	72.49	94.049	90.111	184.161			
7/16/2015	Thursday	74.74	67.639	69.952	137.591			
7/17/2015	Friday	81.46	59.727	71.534	131.261			
7/18/2015	Saturday	80.22	57.046	47.864	104.910			
8/2/2015	Sunday	78.32	41.106	44.332	85.438	1020.92		
8/3/2015	Monday	70.43	69.235	69.360	138.595			
8/4/2015	Tuesday	69.52	62.950	65.025	127.975			
8/5/2015	Wednesday	69.52	83.049	81.360	164.409			
8/6/2015	Thursday	70.80	55.109	67.024	122.132			
8/7/2015	Friday	75.52	89.958	78.290	168.248			
8/8/2015	Saturday	74.16	129.696	84.427	214.123			
8/9/2015	Sunday	73.17	105.655	76.786	182.442	1044.17		
8/10/2015	Monday	71.25	69.656	74.267	143.923			
8/11/2015	Tuesday	71.42	62.282	76.500	138.782			
8/12/2015	Wednesday	71.57	80.482	102.556	183.038			
8/13/2015	Thursday	72.89	63.495	80.169	143.664			
8/14/2015	Friday	76.57	63.306	80.114	143.420			

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
8/15/2015	Saturday	74.82	49.141	59.759	108.899			
8/30/2015	Sunday		0.000	0.000	0.000	975.05		
8/31/2015	Monday		0.000	0.000	0.000			
9/1/2015	Tuesday		0.000	0.000	0.000			
9/2/2015	Wednesday		44.220	84.505	128.725			
9/3/2015	Thursday	78.01	59.047	90.930	149.977			
9/4/2015	Friday	77.89	63.566	84.851	148.417			
9/5/2015	Saturday	79.18	50.863	63.670	114.534			
9/6/2015	Sunday	79.89	50.723	59.374	110.096	1348.57		
9/7/2015	Monday	75.07	68.037	80.816	148.852			
9/8/2015	Tuesday	71.30	72.305	80.140	152.444			
9/9/2015	Wednesday	68.46	76.514	119.094	195.608			
9/10/2015	Thursday	68.94	66.322	105.828	172.149			
9/11/2015	Friday	57.00	139.312	117.364	256.676			
9/12/2015	Saturday	55.91	182.933	129.810	312.742			
9/27/2015	Sunday	67.26	86.907	308.094	395.001	1609.61		
9/28/2015	Monday	69.80	113.556	314.193	427.750			
9/29/2015	Tuesday	61.76	128.588	290.929	419.517			
9/30/2015	Wednesday	51.67	155.860	277.553	433.413			
10/1/2015	Thursday	50.63	151.188	214.125	365.313			
10/2/2015	Friday	50.42	119.118	153.497	272.616			
10/3/2015	Saturday	49.65	1.347	0.000	1.347			
10/4/2015	Sunday	45.74	1.333	0.000	1.333	1046.78		
10/5/2015	Monday	54.66	104.110	141.305	245.415			
10/6/2015	Tuesday	62.17	89.288	110.402	199.690			
10/7/2015	Wednesday	63.50	97.973	163.094	261.067			
10/8/2015	Thursday	65.58	69.991	97.965	167.957			
10/9/2015	Friday	54.66	80.869	88.477	169.345			

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
10/10/2015	Saturday	57.23	1.560	0.414	1.975			
10/25/2015	Sunday	48.15	76.773	149.238	226.011	1288.97		
10/26/2015	Monday	48.33	97.708	108.408	206.117			
10/27/2015	Tuesday	47.87	87.261	92.967	180.228			
10/28/2015	Wednesday	43.21	125.589	133.284	258.873			
10/29/2015	Thursday	40.59	98.170	106.826	204.996			
10/30/2015	Friday	42.90	96.834	114.421	211.255			
10/31/2015	Saturday	46.98	1.383	0.110	1.493			
11/1/2015	Sunday	56.19	1.372	0.020	1.393	1337.18		
11/2/2015	Monday	63.41	73.844	102.101	175.945			
11/3/2015	Tuesday	57.25	75.655	72.110	147.765			
11/4/2015	Wednesday	58.14	116.104	121.631	237.735			
11/5/2015	Thursday	57.35	77.515	96.210	173.726			
11/6/2015	Friday	44.14	122.990	149.384	272.374			
11/7/2015	Saturday	41.46	112.883	215.363	328.246			
11/22/2015	Sunday		0.000	0.000	0.000	1179.46		
11/23/2015	Monday		0.000	0.000	0.000			
11/24/2015	Tuesday		0.000	0.000	0.000			
11/25/2015	Wednesday		104.549	112.931	217.481			
11/26/2015	Thursday	34.61	105.883	130.734	236.618			
11/27/2015	Friday	26.04	109.542	124.475	234.018			
11/28/2015	Saturday	26.30	1.353	0.082	1.435			
11/29/2015	Sunday	31.49	1.386	0.000	1.386	1664.09		
11/30/2015	Monday	33.09	100.794	120.631	221.425			
12/1/2015	Tuesday	30.71	104.458	126.441	230.899			
12/2/2015	Wednesday	32.15	148.529	162.178	310.707			
12/3/2015	Thursday	32.28	105.293	116.622	221.914			
12/4/2015	Friday	37.40	146.288	179.608	325.896			

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
12/5/2015	Saturday	38.74	128.447	223.420	351.867			
12/20/2015	Sunday	42.24	1.359	0.000	1.359	1242.92	740.690	0.18%
12/21/2015	Monday	31.62	102.377	123.350	225.727		1157.480	19.50%
12/22/2015	Tuesday	31.36	102.453	121.783	224.236		1165.120	19.25%
12/23/2015	Wednesday	36.28	148.936	162.371	311.307		1236.810	25.17%
12/24/2015	Thursday	28.07	102.306	124.486	226.792		1077.940	21.04%
12/25/2015	Friday	24.75	111.818	140.336	252.154		1036.310	24.33%
12/26/2015	Saturday	31.77	1.345	0.000	1.345		727.580	0.18%
12/27/2015	Sunday	20.03	118.575	0.000	118.575	1424.43	867.150	13.67%
12/28/2015	Monday	21.56	118.785	163.675	282.460		1180.720	23.92%
12/29/2015	Tuesday	22.72	107.050	141.535	248.585		1188.540	20.92%
12/30/2015	Wednesday	23.79	142.216	176.443	318.659		1255.260	25.39%
12/31/2015	Thursday	17.78	103.063	123.736	226.799		1109.100	20.45%
1/1/2016	Friday	24.52	104.384	123.621	228.005		1010.880	22.56%
1/2/2016	Saturday	20.97	1.345	0.000	1.345		774.430	0.17%
1/17/2015	Sunday		212.685	267.049	479.734	1864.35	1338.170	35.85%
1/18/2015	Monday		152.075	8.673	160.748		1010.730	15.90%
1/19/2015	Tuesday		69.203	138.618	207.821		1258.230	16.52%
1/20/2015	Wednesday		90.741	170.211	260.952		1283.420	20.33%
1/21/2015	Thursday		40.634	68.117	108.751		1338.830	
1/22/2015	Friday		0.000	0.000	0.000		1579.080	
1/23/2015	Saturday		0.000	0.000	0.000		1598.520	
1/24/2016	Sunday		0.000	0.000	0.000		1463.590	
1/25/2016	Monday		0.000	0.000	0.000		1265.580	
1/26/2016	Tuesday		0.000	0.000	0.000		1217.420	
1/27/2016	Wednesday		0.000	0.000	0.000		1289.810	
1/28/2016	Thursday		0.000	0.000	0.000		1195.490	
1/29/2016	Friday		0.000	0.000	0.000		1139.490	

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
1/30/2016	Saturday		0.000	0.000	0.000		692.530	
2/14/2016	Sunday		0.000	0.000	0.000		1271.810	
2/15/2016	Monday		0.000	0.000	0.000		1237.080	
2/16/2016	Tuesday		0.000	0.000	0.000		1368.470	
2/17/2016	Wednesday		0.000	0.000	0.000		1457.270	
2/18/2016	Thursday		0.000	0.000	0.000		1368.650	
2/19/2016	Friday		0.000	0.000	0.000		1259.930	
2/20/2016	Saturday		0.000	0.000	0.000		1707.720	
2/21/2016	Sunday		0.000	0.000	0.000		1818.350	
2/22/2016	Monday		0.000	0.000	0.000		1358.890	
2/23/2016	Tuesday		0.000	0.000	0.000		1366.130	
2/24/2016	Wednesday		0.000	0.000	0.000		1393.560	
2/25/2016	Thursday		0.000	0.000	0.000		1400.150	
2/26/2016	Friday		0.000	0.000	0.000		1285.290	
2/27/2016	Saturday		0.000	0.000	0.000		1107.700	
3/13/2016	Sunday		0.000	0.000	0.000			
3/14/2016	Monday		0.000	0.000	0.000			
3/15/2016	Tuesday		0.000	0.000	0.000			
3/16/2016	Wednesday		0.000	0.000	0.000			
3/17/2016	Thursday		0.000	0.000	0.000			
3/18/2016	Friday		0.000	0.000	0.000			
3/19/2016	Saturday		0.000	0.000	0.000			
3/20/2016	Sunday		0.000	0.000	0.000			
3/21/2016	Monday		0.000	0.000	0.000			
3/22/2016	Tuesday		0.000	0.000	0.000			
3/23/2016	Wednesday		0.000	0.000	0.000			
3/24/2016	Thursday		0.000	0.000	0.000			
3/25/2016	Friday		0.000	0.000	0.000			

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
3/26/2016	Saturday		0.000	0.000	0.000			
4/10/2016	Sunday		0.000	0.000	0.000			
4/11/2016	Monday		0.000	0.000	0.000			
4/12/2016	Tuesday		0.000	0.000	0.000		1151.760	
4/13/2016	Wednesday		0.000	0.000	0.000		1088.220	
4/14/2016	Thursday		0.000	0.000	0.000		1001.520	
4/15/2016	Friday		0.000	0.000	0.000		944.340	
4/16/2016	Saturday		0.000	0.000	0.000		684.540	
4/17/2016	Sunday	65.82	0.002	0.000	0.002	978.24	640.550	0.00%
4/18/2016	Monday	64.53	53.119	86.403	139.522		989.940	14.09%
4/19/2016	Tuesday	53.22	66.942	92.620	159.562		1003.990	15.89%
4/20/2016	Wednesday	53.68	113.780	145.030	258.810		1069.540	24.20%
4/21/2016	Thursday	55.05	88.633	132.873	221.506		1007.570	21.98%
4/22/2016	Friday	52.78	80.291	118.542	198.833		1052.990	18.88%
4/23/2016	Saturday	57.30	0.002	0.000	0.002		644.360	0.00%
5/8/2016	Sunday		0.000	0.000	0.000		664.860	
5/9/2016	Monday		0.000	0.000	0.000		1051.220	
5/10/2016	Tuesday		0.000	0.000	0.000		1038.410	
5/11/2016	Wednesday		0.000	0.000	0.000		1149.750	
5/12/2016	Thursday		0.000	0.000	0.000		1101.460	
5/13/2016	Friday		0.000	0.000	0.000		1247.300	
5/14/2016	Saturday		0.000	0.000	0.000		1759.320	
5/15/2016	Sunday		0.000	0.000	0.000		1464.470	
5/16/2016	Monday		0.000	0.000	0.000		1038.670	
5/17/2016	Tuesday		0.000	0.000	0.000		858.440	
5/18/2016	Wednesday		0.000	0.000	0.000		1025.800	
5/19/2016	Thursday		0.000	0.000	0.000		941.090	
5/20/2016	Friday		0.000	0.000	0.000		1055.650	

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
5/21/2016	Saturday		0.000	0.000	0.000		1311.720	
6/5/2016	Sunday		0.000	0.000	0.000	777.50	732.460	0.00%
6/6/2016	Monday		0.000	0.000	0.000		1009.720	
6/7/2016	Tuesday	64.68	34.969	62.792	97.761		972.080	10.06%
6/8/2016	Wednesday	70.99	93.798	150.650	244.448		988.130	24.74%
6/9/2016	Thursday	81.03	65.689	99.497	165.186		940.880	17.56%
6/10/2016	Friday	83.95	46.919	66.615	113.535		1089.330	10.42%
6/11/2016	Saturday	81.28	1.334	0.000	1.334		865.540	0.15%
6/26/2016	Sunday		0.000	0.000	0.000			
6/27/2016	Monday		0.000	0.000	0.000			
6/28/2016	Tuesday		0.000	0.000	0.000			
6/29/2016	Wednesday		0.000	0.000	0.000			
6/30/2016	Thursday		0.000	0.000	0.000			
7/1/2016	Friday		0.000	0.000	0.000			
7/2/2016	Saturday		0.000	0.000	0.000			
7/3/2016	Sunday		1.344	0.000	1.344			
7/4/2016	Monday		7.711	10.889	18.600			
7/5/2016	Tuesday		0.000	0.000	0.000			
7/6/2016	Wednesday		0.000	0.000	0.000			
7/7/2016	Thursday		0.000	0.000	0.000			
7/8/2016	Friday		0.000	0.000	0.000			
7/9/2016	Saturday		0.000	0.000	0.000			
7/24/2016	Sunday		0.000	0.000	0.000	719.76	882.030	
7/25/2016	Monday		0.696	0.000	0.696		1687.900	
7/26/2016	Tuesday	74.97	78.640	64.776	143.416		1537.410	9.33%
7/27/2016	Wednesday		93.472	84.173	177.645		1690.870	
7/28/2016	Thursday		0.000	0.000	0.000		1509.140	
7/29/2016	Friday		58.122	56.600	114.722		1480.620	

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
7/30/2016	Saturday	70.97	1.339	0.000	1.339		860.610	0.16%
7/31/2016	Sunday	73.07	1.341	0.000	1.341	799.21	885.950	0.15%
8/1/2016	Monday	71.17	91.878	65.591	157.469		1595.750	9.87%
8/2/2016	Tuesday	72.74	74.013	82.405	156.418		1605.170	9.74%
8/3/2016	Wednesday	75.73	89.333	107.889	197.223		1937.850	10.18%
8/4/2016	Thursday	78.47	58.496	68.355	126.852		1951.670	6.50%
8/5/2016	Friday	70.89	75.638	82.934	158.571		1863.480	8.51%
8/6/2016	Saturday	68.74	1.336	0.000	1.336		885.840	0.15%
8/21/2016	Sunday	63.08	1.342	0.000	1.342	1473.59	1020.910	0.13%
8/22/2016	Monday	73.32	52.048	90.569	142.617		1481.250	9.63%
8/23/2016	Tuesday	72.13	50.296	75.854	126.150		1639.401	7.69%
8/24/2016	Wednesday	72.97	108.156	117.677	225.834		1977.215	11.42%
8/25/2016	Thursday	68.44	102.854	107.093	209.947		1619.348	12.96%
8/26/2016	Friday	63.87	116.775	212.889	329.663		1896.004	17.39%
8/27/2016	Saturday	67.14	82.415	355.621	438.036		2331.478	18.79%
8/28/2016	Sunday	73.40	77.466	240.581	318.048	1417.91	2268.528	14.02%
8/29/2016	Monday	72.64	103.593	78.165	181.758		1951.801	9.31%
8/30/2016	Tuesday	71.80	103.090	90.496	193.586		2004.756	9.66%
8/31/2016	Wednesday	68.43	107.688	140.563	248.250		1886.815	13.16%
9/1/2016	Thursday	64.81	97.001	101.868	198.869		1699.803	11.70%
9/2/2016	Friday	63.39	100.220	97.003	197.224		1487.272	13.26%
9/3/2016	Saturday	64.91	80.179	0.000	80.179		1196.074	6.70%
9/18/2016	Sunday	68.53	82.849	193.104	275.954	1365.09	4571.659	6.04%
9/19/2016	Monday	70.66	106.740	76.476	183.216		1839.531	9.96%
9/20/2016	Tuesday	73.12	93.410	109.919	203.330		1796.847	11.32%
9/21/2016	Wednesday	81.89	88.563	127.638	216.201		2160.027	10.01%
9/22/2016	Thursday	73.43	97.150	107.562	204.712		2025.116	10.11%
9/23/2016	Friday	73.53	104.143	93.190	197.333		1944.764	10.15%

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
9/24/2016	Saturday	73.37	84.340	0.000	84.340		1619.849	5.21%
9/25/2016	Sunday	63.29	99.913	0.078	99.992	1519.14	1214.372	8.23%
9/26/2016	Monday	59.38	120.610	120.509	241.119		1440.923	16.73%
9/27/2016	Tuesday	61.08	113.906	142.572	256.478		1510.815	16.98%
9/28/2016	Wednesday	54.26	153.759	162.915	316.674		1491.898	21.23%
9/29/2016	Thursday	57.00	129.323	117.369	246.692		1465.591	16.83%
9/30/2016	Friday	57.78	143.571	102.605	246.177			
10/1/2016	Saturday	61.38	107.941	4.071	112.012			
10/16/2016	Sunday	67.14	1.329	0.000	1.329	1260.69		
10/17/2016	Monday	73.10	50.127	68.863	118.990			
10/18/2016	Tuesday	60.45	113.786	107.797	221.583			
10/19/2016	Wednesday	56.26	160.512	129.622	290.134			
10/20/2016	Thursday	44.12	149.643	106.562	256.205			
10/21/2016	Friday	44.75	155.739	125.999	281.738			
10/22/2016	Saturday	53.47	90.685	0.029	90.714			
10/23/2016	Sunday	55.45	103.654	0.000	103.654			
10/24/2016	Monday	47.69	103.506	0.000	103.506			
10/25/2016	Tuesday	52.69	103.506	0.000	103.506			
10/26/2016	Wednesday	49.95	103.506	0.000	103.506			
10/27/2016	Thursday	50.76	103.506	0.000	103.506			
10/28/2016	Friday	62.30	111.353	92.375	203.728			
10/29/2016	Saturday	60.06	50.107	0.000	50.107			
11/13/2016	Sunday	49.49	1.362	0.000	1.362	1342.33	868.731	0.16%
11/14/2016	Monday	47.12	1.344	96.227	97.571		1199.298	
11/15/2016	Tuesday	47.92	1.340	175.759	177.098		1336.424	
11/16/2016	Wednesday	51.21	108.370	153.435	261.805		1611.229	16.25%
11/17/2016	Thursday	59.23	129.617	173.265	302.883		1741.447	17.39%
11/18/2016	Friday	40.61	142.164	0.000	142.164		1240.478	11.46%

Fixed Static Pressure								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
11/19/2016	Saturday	29.89	108.693	0.000	108.693		1027.956	10.57%
					0			
11/20/2016	Sunday	27.01	209.456	0.000	209.456	1537.72	1189.649	17.61%
11/21/2016	Monday	34.39	161.810	120.493	282.303		1459.184	19.35%
11/22/2016	Tuesday	37.61	107.527	163.520	271.048		1402.704	19.32%
11/23/2016	Wednesday	37.45	144.817	245.689	390.506		1444.880	27.03%
11/24/2016	Thursday	36.65	105.618	173.474	279.092		1172.184	23.81%
11/25/2016	Friday	38.02	103.966	0.000	103.966		974.034	10.67%
11/26/2016	Saturday	42.70	1.347	0.000	1.347		891.266	0.15%

Site #4:

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
7/19/2015	Sunday	74.52	0.000	28.612	28.612	777.310		
7/20/2015	Monday	72.96	44.377	53.105	97.481			
7/21/2015	Tuesday	68.46	38.701	57.955	96.656			
7/22/2015	Wednesday	68.71	39.337	80.153	119.490			
7/23/2015	Thursday	71.65	20.649	61.895	82.543			
7/24/2015	Friday	75.66	57.789	70.401	128.190			
7/25/2015	Saturday	79.13	78.929	66.479	145.408			
7/26/2015	Sunday	76.37	68.027	60.773	128.800	861.932		
7/27/2015	Monday	72.66	52.155	60.772	112.927			
7/28/2015	Tuesday	72.77	51.784	63.905	115.689			
7/29/2015	Wednesday	73.70	68.095	80.787	148.883			
7/30/2015	Thursday	73.91	61.261	63.393	124.654			
7/31/2015	Friday	74.62	80.039	31.012	111.051			
8/1/2015	Saturday	75.17	57.301	62.627	119.928			
8/16/2015	Sunday		0.000	0.000	0.000			
8/17/2015	Monday		0.000	0.000	0.000			
8/18/2015	Tuesday		0.000	0.000	0.000			
8/19/2015	Wednesday		0.000	0.000	0.000			
8/20/2015	Thursday		0.000	0.000	0.000			
8/21/2015	Friday		0.000	0.000	0.000			
8/22/2015	Saturday		0.000	0.000	0.000			
8/23/2015	Sunday		0.000	0.000	0.000			
8/24/2015	Monday		0.000	0.000	0.000			
8/25/2015	Tuesday		0.000	0.000	0.000			
8/26/2015	Wednesday		0.000	0.000	0.000			
8/27/2015	Thursday		0.000	0.000	0.000			
8/28/2015	Friday		0.000	0.000	0.000			

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
8/29/2015	Saturday		0.000	0.000	0.000			
9/13/2015	Sunday	60.65	116.280	0.000	116.280	954.878		
9/14/2015	Monday	69.29	65.294	42.902	108.197			
9/15/2015	Tuesday	74.31	61.310	115.464	176.775			
9/16/2015	Wednesday	74.92	74.481	151.374	225.855			
9/17/2015	Thursday	75.10	60.962	187.309	248.271			
9/18/2015	Friday	60.30	84.170	305.310	389.480			
9/19/2015	Saturday	57.58	24.066	309.282	333.348			
9/20/2015	Sunday	60.21	28.264	331.665	359.929			
9/21/2015	Monday	64.93	93.109	313.051	406.160			
9/22/2015	Tuesday	71.14	80.023	314.227	394.250			
9/23/2015	Wednesday	67.28	116.002	351.635	467.637			
9/24/2015	Thursday	68.76	74.819	315.190	390.009			
9/25/2015	Friday	68.20	75.284	302.802	378.086			
9/26/2015	Saturday	66.02	23.541	300.660	324.200			
10/11/2015	Sunday	69.22	2.018	0.864	2.882	819.993		
10/12/2015	Monday	63.03	52.766	85.288	138.054			
10/13/2015	Tuesday	53.70	60.486	93.771	154.257			
10/14/2015	Wednesday	54.82	82.391	127.602	209.993			
10/15/2015	Thursday	55.77	63.455	82.695	146.150			
10/16/2015	Friday	44.12	71.329	95.989	167.318			
10/17/2015	Saturday	43.26	1.339	0.000	1.339			
10/18/2015	Sunday	49.09	1.382	1.184	2.566	1232.519		
10/19/2015	Monday	65.85	67.077	121.258	188.336			
10/20/2015	Tuesday	63.59	60.127	104.469	164.595			
10/21/2015	Wednesday	58.16	86.038	137.883	223.921			
10/22/2015	Thursday	53.04	69.924	90.374	160.299			
10/23/2015	Friday	56.97	87.727	177.735	265.462			

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
10/24/2015	Saturday	52.57	44.277	183.064	227.340			
11/8/2015	Sunday	44.27	46.747	200.052	246.799	1248.181		
11/9/2015	Monday	43.76	96.956	176.287	273.243			
11/10/2015	Tuesday	46.70	87.126	0.000	87.126			
11/11/2015	Wednesday	49.47	113.412	0.000	113.412			
11/12/2015	Thursday	42.37	82.420	49.162	131.582			
11/13/2015	Friday	39.17	88.025	93.815	181.839			
11/14/2015	Saturday	47.74	1.337	0.000	1.337			
11/15/2015	Sunday	52.03	0.200	0.000	0.200			
11/16/2015	Monday		0.000	0.000	0.000			
11/17/2015	Tuesday		0.000	0.000	0.000			
11/18/2015	Wednesday	45.97	33.472	49.617	83.090			
11/19/2015	Thursday		0.000	0.000	0.000			
11/20/2015	Friday		0.000	0.000	0.000			
11/21/2015	Saturday		0.000	0.000	0.000			
12/6/2015	Sunday	37.37	59.895	165.676	225.571	1328.218		
12/7/2015	Monday	38.23	92.546	113.132	205.678			
12/8/2015	Tuesday	41.51	88.887	105.938	194.826		1078.703	18.06%
12/9/2015	Wednesday	43.36	117.931	139.522	257.453		1111.560	23.16%
12/10/2015	Thursday	49.19	91.098	143.741	234.839		1032.110	22.75%
12/11/2015	Friday	41.94	80.319	128.079	208.397		987.190	21.11%
12/12/2015	Saturday	41.35	1.173	0.281	1.454		722.870	0.20%
12/13/2015	Sunday	43.69	1.154	0.041	1.195	1045.212	764.900	0.16%
12/14/2015	Monday	37.35	83.186	109.960	193.145		1142.830	16.90%
12/15/2015	Tuesday	35.32	88.574	100.537	189.112		1100.920	17.18%
12/16/2015	Wednesday	33.55	131.470	156.539	288.008		1235.240	23.32%
12/17/2015	Thursday	28.93	86.363	0.000	86.363		945.180	9.14%
12/18/2015	Friday	22.47	82.192	89.560	171.751		1076.570	15.95%

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
12/19/2015	Saturday	23.89	1.342	0.147	1.489		752.090	0.20%
1/3/2016	Sunday	22.06	3.067	0.000	3.067	1202.055	778.350	0.39%
1/4/2016	Monday	21.76	128.322	106.819	235.141		1246.180	18.87%
1/5/2016	Tuesday	24.25	77.694	122.025	199.719		1192.800	16.74%
1/6/2016	Wednesday	30.61	118.056	164.637	282.692		1292.300	21.88%
1/7/2016	Thursday	32.94	104.844	188.200	293.045		1286.670	
1/8/2016	Friday	31.54	141.730	261.126	402.856		1675.230	
1/9/2016	Saturday	6.98	79.213	298.701	377.914		1954.020	
1/10/2016	Sunday	-1.67	64.482	245.501	309.983		1769.400	17.52%
1/11/2016	Monday	15.09	87.028	105.418	192.446		1253.680	15.35%
1/12/2016	Tuesday	2.54	90.292	75.052	165.344		1241.400	
1/13/2016	Wednesday	24.77	144.447	216.020	360.467		1353.800	
1/14/2016	Thursday	36.54	132.532	262.547	395.079		1401.860	
1/15/2016	Friday	18.94	158.901	272.410	431.312		1480.100	
1/16/2016	Saturday	6.67	179.220	335.227	514.447		1374.110	
1/31/2016	Sunday		0.000	0.000	0.000		703.730	
2/1/2016	Monday		0.000	0.000	0.000		1216.260	
2/2/2016	Tuesday		0.000	0.000	0.000		1160.150	
2/3/2016	Wednesday		0.000	0.000	0.000		1300.390	
2/4/2016	Thursday		0.000	0.000	0.000		1499.250	
2/5/2016	Friday		0.000	0.000	0.000		1467.850	
2/6/2016	Saturday		0.000	0.000	0.000		1425.260	
2/7/2016	Sunday		0.000	0.000	0.000		1382.660	
2/8/2016	Monday		0.000	0.000	0.000		1473.120	
2/9/2016	Tuesday		0.000	0.000	0.000		1561.470	
2/10/2016	Wednesday		0.000	0.000	0.000		1517.550	
2/11/2016	Thursday		0.000	0.000	0.000		1474.620	
2/12/2016	Friday		0.000	0.000	0.000		1389.840	

TTR								
Date		Average Daily Temp.	AHU-1 Total	AHU-2 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	%
2/13/2016	Saturday		0.000	0.000	0.000		1305.600	
2/28/2016	Sunday		0.000	0.000	0.000		1090.250	
2/29/2016	Monday		0.000	0.000	0.000		1275.240	
3/1/2016	Tuesday		0.000	0.000	0.000		1433.730	
3/2/2016	Wednesday		0.000	0.000	0.000		1415.180	
3/3/2016	Thursday		0.000	0.000	0.000		1401.620	
3/4/2016	Friday		0.000	0.000	0.000		1398.850	
3/5/2016	Saturday		0.000	0.000	0.000		1470.570	
3/6/2016	Sunday		0.000	0.000	0.000			
3/7/2016	Monday		0.000	0.000	0.000			
3/8/2016	Tuesday		0.000	0.000	0.000			
3/9/2016	Wednesday		0.000	0.000	0.000			
3/10/2016	Thursday		0.000	0.000	0.000			
3/11/2016	Friday		0.000	0.000	0.000			
3/12/2016	Saturday		0.000	0.000	0.000			
3/27/2016	Sunday		0.000	0.000	0.000			
3/28/2016	Monday		0.000	0.000	0.000			
3/29/2016	Tuesday		0.000	0.000	0.000			
3/30/2016	Wednesday		0.000	0.000	0.000			
3/31/2016	Thursday		0.000	0.000	0.000			
4/1/2016	Friday		0.000	0.000	0.000			
4/2/2016	Saturday		0.000	0.000	0.000			
4/3/2016	Sunday		0.000	0.000	0.000			
4/4/2016	Monday		0.000	0.000	0.000			
4/5/2016	Tuesday		0.000	0.000	0.000			
4/6/2016	Wednesday		0.000	0.000	0.000			
4/7/2016	Thursday		0.000	0.000	0.000			
4/8/2016	Friday		0.000	0.000	0.000			

TTR								
Date		Average Daily Temp.	AHU-1 Total	AHU-2 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	%
4/9/2016	Saturday		0.000	0.000	0.000			
4/24/2016	Sunday		0.000	0.000	0.000			
4/25/2016	Monday		0.000	0.000	0.000			
4/26/2016	Tuesday		0.000	0.000	0.000			
4/27/2016	Wednesday		0.000	0.000	0.000			
4/28/2016	Thursday		0.000	0.000	0.000			
4/29/2016	Friday		0.000	0.000	0.000			
4/30/2016	Saturday		0.000	0.000	0.000			
5/1/2016	Sunday		0.000	0.000	0.000			
5/2/2016	Monday		0.000	0.000	0.000			
5/3/2016	Tuesday		0.000	0.000	0.000			
5/4/2016	Wednesday		0.000	0.000	0.000			
5/5/2016	Thursday		0.000	0.000	0.000			
5/6/2016	Friday		0.000	0.000	0.000			
5/7/2016	Saturday		0.000	0.000	0.000			
5/22/2016	Sunday		0.000	0.000	0.000		1158.480	
5/23/2016	Monday		0.000	0.000	0.000		946.590	
5/24/2016	Tuesday		0.000	0.000	0.000		948.470	
5/25/2016	Wednesday		0.000	0.000	0.000		961.710	
5/26/2016	Thursday		0.000	0.000	0.000		912.530	
5/27/2016	Friday		0.000	0.000	0.000		876.650	
5/28/2016	Saturday		0.000	0.000	0.000		649.820	
5/29/2016	Sunday		0.000	0.000	0.000		615.410	
5/30/2016	Monday		0.000	0.000	0.000		740.340	
5/31/2016	Tuesday		0.000	0.000	0.000		932.330	
6/1/2016	Wednesday		0.000	0.000	0.000		1083.360	
6/2/2016	Thursday		0.000	0.000	0.000		1310.300	
6/3/2016	Friday		0.000	0.000	0.000		1229.240	

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
6/4/2016	Saturday		0.000	0.000	0.000		782.070	
6/12/2016	Sunday	83.29	1.331	0.000	1.331	659.085		
6/13/2016	Monday	77.42	28.918	43.335	72.253			
6/14/2016	Tuesday	77.03	83.819	86.586	170.405			
6/15/2016	Wednesday	78.36	86.852	86.287	173.138			
6/16/2016	Thursday	75.12	55.935	60.358	116.293			
6/17/2016	Friday	75.86	59.969	64.365	124.333			
6/18/2016	Saturday	77.23	1.332	0.000	1.332			
6/19/2016	Sunday	78.85	1.334	0.000	1.334			
6/20/2016	Monday	78.27	64.118	61.768	125.886			
6/21/2016	Tuesday		0.000	0.000	0.000			
6/22/2016	Wednesday		0.000	0.000	0.000			
6/23/2016	Thursday		0.000	0.000	0.000			
6/24/2016	Friday		0.000	0.000	0.000			
6/25/2016	Saturday		0.000	0.000	0.000			
7/10/2016	Sunday		0.000	0.000	0.000	1423.661		
7/11/2016	Monday	80.32	40.106	51.308	91.414			
7/12/2016	Tuesday	73.63	68.178	68.080	136.258			
7/13/2016	Wednesday	75.02	80.285	94.999	175.284			
7/14/2016	Thursday	72.96	30.265	99.855	130.120			
7/15/2016	Friday	65.62	1.586	175.318	176.904			
7/16/2016	Saturday	70.00	1.320	323.907	325.227			
7/17/2016	Sunday	74.62	1.322	253.838	255.160	1213.759		
7/18/2016	Monday	75.96	48.735	44.586	93.321			
7/19/2016	Tuesday	70.97	95.846	92.208	188.054		1658.583	11.34%
7/20/2016	Wednesday	79.66	184.298	95.899	280.197		1988.870	14.09%
7/21/2016	Thursday		0.000	0.000	0.000		2040.470	0.00%
7/22/2016	Friday		0.000	0.000	0.000		2085.140	0.00%

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
7/23/2016	Saturday		0.000	0.000	0.000		992.880	0.00%
8/7/2016	Sunday	68.84	1.337	0.000	1.337	1143.022	884.450	0.15%
8/8/2016	Monday	70.23	55.733	52.803	108.536		1552.970	6.99%
8/9/2016	Tuesday	74.95	50.408	46.251	96.659		1518.390	6.37%
8/10/2016	Wednesday	76.59	69.910	81.420	151.331		1806.186	8.38%
8/11/2016	Thursday	75.66	57.328	107.197	164.525		1907.374	8.63%
8/12/2016	Friday	73.73	76.322	202.680	279.002		2369.600	11.77%
8/13/2016	Saturday	72.87	24.528	317.104	341.632		2321.790	14.71%
8/14/2016	Sunday	72.54	1.362	251.801	253.164	938.953	1790.420	14.14%
8/15/2016	Monday	70.81	40.534	78.256	118.790		1475.840	8.05%
8/16/2016	Tuesday	73.53	55.779	95.668	151.448		1532.110	9.88%
8/17/2016	Wednesday	74.82	65.863	100.188	166.050		1710.300	9.71%
8/18/2016	Thursday	78.27	53.759	69.267	123.027		1745.300	7.05%
8/19/2016	Friday	75.05	62.559	62.578	125.137		1841.370	6.80%
8/20/2016	Saturday	66.12	1.338	0.000	1.338		1128.900	0.12%
9/4/2016	Sunday	68.08	18.700	0.000	18.700	679.369	1103.445	1.69%
9/5/2016	Monday	76.09	37.989	73.515	111.504		1489.934	7.48%
9/6/2016	Tuesday	81.23	21.402	62.081	83.483		1775.244	4.70%
9/7/2016	Wednesday	72.65	69.714	108.884	178.597		1861.853	9.59%
9/8/2016	Thursday	72.49	1.423	103.084	104.506		1567.151	6.67%
9/9/2016	Friday	69.26	58.014	101.888	159.901		1660.028	9.63%
9/10/2016	Saturday	62.25	22.677	0.000	22.677		1081.881	2.10%
9/11/2016	Sunday	64.91	18.076	0.000	18.076	991.818	1129.813	1.60%
9/12/2016	Monday	69.75	47.795	72.341	120.136		1653.127	7.27%
9/13/2016	Tuesday	63.92	57.959	62.385	120.344		1476.783	8.15%
9/14/2016	Wednesday	63.13	49.366	119.398	168.764		1618.593	10.43%
9/15/2016	Thursday	69.39	49.578	91.099	140.678		1756.367	8.01%
9/16/2016	Friday	65.52	55.481	149.399	204.880		2005.258	10.22%

TTR								
Date		**Average Daily Temp.**	**AHU-1 Total**	**AHU-2 Total**	**All RTUs**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(corrected)**	**(corrected)**	**(corrected)**	**Corrected nominal weekly**		
			kWh	**kWh**	**kWh**	**kWh**	**kWh**	**%**
9/17/2016	Saturday	62.68	14.058	204.882	218.941		2241.951	9.77%
10/2/2016	Sunday	62.19	29.641	2.571	32.212	517.683		
10/3/2016	Monday	61.41	2.973	79.950	82.924			
10/4/2016	Tuesday	66.15	3.101	92.435	95.536			
10/5/2016	Wednesday	61.51	1.356	134.041	135.397			
10/6/2016	Thursday	61.18	3.147	104.093	107.240			
10/7/2016	Friday	48.55	1.361	104.593	105.953			
10/8/2016	Saturday	54.69	1.338	0.000	1.338			
10/9/2016	Sunday	52.79	1.333	0.000	1.333			
10/10/2016	Monday	57.25	1.325	118.001	119.326			
10/11/2016	Tuesday	62.80	1.311	124.118	125.429			
10/12/2016	Wednesday	44.88	1.324	131.315	132.639			
10/13/2016	Thursday	42.19	1.325	112.592	113.917			
10/14/2016	Friday	51.13	1.319	101.418	102.736			
10/15/2016	Saturday	65.54	1.339	0.000	1.339			
10/30/2016	Sunday	48.30	50.142	0.000	50.142			
10/31/2016	Monday	53.37	67.640	55.739	123.379			
11/1/2016	Tuesday	60.47	68.516	132.744	201.260		1396.243	
11/2/2016	Wednesday	59.12	1.330	179.571	180.900		1408.837	
11/3/2016	Thursday	59.07	1.328	147.736	149.065		1426.019	
11/4/2016	Friday	59.01	1.324	143.707	145.030		1376.912	
11/5/2016	Saturday	58.36	1.338	0.000	1.338		1472.498	
11/6/2016	Sunday	58.90	1.340	0.000	1.340		1425.184	
11/7/2016	Monday	50.62	1.331	117.833	119.164		1264.161	
11/8/2016	Tuesday	58.77	1.327	120.874	122.202		1212.069	
11/9/2016	Wednesday	46.66	1.343	184.022	185.366		1296.619	
11/10/2016	Thursday	53.14	1.351	166.024	167.375		1329.323	
11/11/2016	Friday	43.60	1.352	0.000	1.352		920.636	

TTR								
Date		Average Daily Temp.	AHU-1 Total	AHU-2 Total	All RTUs		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(corrected)	(corrected)	(corrected)	Corrected nominal weekly		
			kWh	kWh	kWh	kWh	kWh	%
11/12/2016	Saturday	42.65	1.351	0.000	1.351		845.903	
11/27/2016	Sunday	40.82	1.341	0.000	1.341	1272.695		
11/28/2016	Monday	49.87	77.689	101.691	179.379			
11/29/2016	Tuesday	37.04	85.973	160.363	246.336			
11/30/2016	Wednesday	33.83	109.666	239.332	348.998			
12/1/2016	Thursday	33.77	95.981	163.836	259.817			
12/2/2016	Friday	34.34	74.520	160.962	235.482			
12/3/2016	Saturday	34.98	1.341	0.000	1.341			
12/4/2016	Sunday	32.64	1.333	0.000	1.333	1691.110		
12/5/2016	Monday	35.81	82.076	158.050	240.126			
12/6/2016	Tuesday	26.86	83.048	161.084	244.132			
12/7/2016	Wednesday	17.93	142.616	237.042	379.658			
12/8/2016	Thursday	16.11	104.569	199.493	304.063			
12/9/2016	Friday	15.08	96.348	166.264	262.612			
12/10/2016	Saturday	21.33	30.907	228.278	259.185			

Site #5:

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
8/2/2015	Sunday	80.50	9.637	10.636	8.258	9.134	19.771	505.439		
8/3/2015	Monday	71.80	68.567	80.222	33.743	39.513	119.734			
8/4/2015	Tuesday	69.50	59.507	69.772	29.485	34.616	104.388			
8/5/2015	Wednesday	71.14	48.958	57.793	25.418	30.039	87.832			
8/6/2015	Thursday	72.28	44.670	52.655	23.382	27.597	80.252			
8/7/2015	Friday	76.56	41.013	48.358	21.448	25.333	73.691		1112.078	6.63%
8/8/2015	Saturday		0.000	0.000	0.000	0.000	0.000		603.975	
8/9/2015	Sunday	74.95	9.647	10.663	8.377	9.273	19.936	506.605	608.433	3.28%
8/10/2015	Monday	73.93	60.682	71.469	30.390	35.840	107.309		1326.318	8.09%
8/11/2015	Tuesday	72.47	48.547	57.233	25.320	29.876	87.109		1225.948	7.11%
8/12/2015	Wednesday	71.52	50.888	60.027	26.127	30.837	90.864		1247.533	7.28%
8/13/2015	Thursday	74.54	53.122	62.620	26.970	31.824	94.444		1299.970	7.27%
8/14/2015	Friday	77.74	48.700	57.481	25.173	29.750	87.230		1240.603	7.03%
8/15/2015	Saturday	76.01	9.540	10.526	8.307	9.185	19.711		602.220	3.27%
8/16/2015	Sunday	77.03	9.570	10.547	8.288	9.150	19.697	444.843	620.631	3.17%
8/17/2015	Monday	71.60	69.975	82.308	33.997	40.089	122.397		1270.639	9.63%
8/18/2015	Tuesday	67.19	46.052	54.288	23.995	28.329	82.617		1141.608	7.24%
8/19/2015	Wednesday	60.52	33.113	38.910	17.578	20.699	59.609		946.499	6.30%
8/20/2015	Thursday	65.87	35.163	41.545	18.645	22.063	63.608		1039.502	6.12%
8/21/2015	Friday	71.07	43.205	50.863	22.302	26.288	77.151		1046.052	7.38%
8/22/2015	Saturday	71.22	9.532	10.516	8.370	9.251	19.766		607.924	3.25%
8/23/2015	Sunday	63.71	9.643	10.651	8.548	9.460	20.110	385.110	562.997	3.57%
8/24/2015	Monday	62.55	41.673	49.244	21.657	25.625	74.869		1027.960	7.28%
8/25/2015	Tuesday	62.88	39.377	46.745	21.108	25.086	71.831		1052.850	6.82%
8/26/2015	Wednesday	61.66	38.707	45.884	20.363	24.172	70.056		1045.310	6.70%
8/27/2015	Thursday	63.18	36.243	42.712	18.967	22.393	65.105		1031.580	6.31%

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
8/28/2015	Friday	67.21	35.248	41.417	18.555	21.842	63.258		1039.290	6.09%
8/29/2015	Saturday	67.26	9.560	10.556	8.428	9.324	19.880		624.27	3.18%
8/30/2015	Sunday	65.82	9.492	10.477	8.440	9.338	19.814	600.355	623.240	3.18%
8/31/2015	Monday	74.15	43.243	51.064	22.837	27.008	78.072		1280.580	6.10%
9/1/2015	Tuesday	77.43	75.908	89.720	35.948	42.612	132.332		1186.960	11.15%
9/2/2015	Wednesday	78.17	96.162	113.785	43.902	52.142	165.927		1369.990	12.11%
9/3/2015	Thursday	79.71	54.715	64.522	27.688	32.672	97.195		1483.890	6.55%
9/4/2015	Friday	79.56	45.510	53.775	23.535	27.855	81.631		1224.850	6.66%
9/5/2015	Saturday	80.47	13.368	14.832	9.492	10.552	25.384		773.99	3.28%
9/20/2015	Sunday	59.15	11.727	13.208	4.412	5.183	18.391	345.447	573.670	3.21%
9/21/2015	Monday	64.88	40.510	48.017	11.388	12.880	60.897		1092.760	5.57%
9/22/2015	Tuesday	71.65	44.057	52.311	12.972	14.839	67.151		1186.100	5.66%
9/23/2015	Wednesday	69.85	41.003	48.662	11.715	13.274	61.936		1128.350	5.49%
9/24/2015	Thursday	69.60	40.927	48.584	11.698	13.250	61.833		1165.750	5.30%
9/25/2015	Friday	68.52	37.905	44.829	10.348	11.611	56.439		1048.960	5.38%
9/26/2015	Saturday	66.39	11.822	13.295	4.675	5.505	18.801		602.79	3.12%
9/27/2015	Sunday	66.10	11.852	13.352	4.217	4.955	18.307		610.880	3.00%
9/28/2015	Monday	69.95	45.780	54.051	13.373	15.310	69.361		1201.330	
9/29/2015	Tuesday	62.13	52.893	62.467	14.857	16.986	79.454		1034.710	
9/30/2015	Wednesday	52.11	6.850	8.138	2.180	2.559	10.697		1059.960	
10/1/2015	Thursday								982.610	
10/2/2015	Friday	51.24	49.462	58.316	13.375	15.356	73.671		898.660	
10/3/2015	Saturday	50.85	11.850	13.330	4.730	5.564	18.894		572.71	3.30%
10/18/2015	Sunday							576.754	582.720	
10/19/2015	Monday								1087.620	
10/20/2015	Tuesday								1070.790	
10/21/2015	Wednesday	59.99	13.627	16.020	4.053	4.555	20.575		1089.870	
10/22/2015	Thursday	56.17	65.020	76.125	17.883	19.855	95.980		1102.820	

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
10/23/2015	Friday	58.72	63.933	74.759	17.853	19.835	94.594		986.890	9.59%
10/24/2015	Saturday	53.99	34.133	38.063	11.933	13.829	51.892		594.46	8.73%
10/25/2015	Sunday	47.63	18.477	20.828	6.233	7.197	28.025	326.845		
10/26/2015	Monday	49.19	36.237	42.758	10.173	11.400	54.159			
10/27/2015	Tuesday									
10/28/2015	Wednesday									
10/29/2015	Thursday									
10/30/2015	Friday									
10/31/2015	Saturday									
11/15/2015	Sunday									
11/16/2015	Monday									
11/17/2015	Tuesday									
11/18/2015	Wednesday									
11/19/2015	Thursday									
11/20/2015	Friday									
11/21/2015	Saturday									
11/22/2015	Sunday									
11/23/2015	Monday									
11/24/2015	Tuesday									
11/25/2015	Wednesday									
11/26/2015	Thursday									
11/27/2015	Friday									
11/28/2015	Saturday									
12/13/2015	Sunday									
12/14/2015	Monday									
12/15/2015	Tuesday								839.500	
12/16/2015	Wednesday								833.970	
12/17/2015	Thursday								856.340	

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
12/18/2015	Friday								828.010	
12/19/2015	Saturday								500.330	
12/20/2015	Sunday							295.422	476.200	
12/21/2015	Monday								839.730	
12/22/2015	Tuesday								863.020	
12/23/2015	Wednesday	39.55	49.622	58.696	13.355	15.041	73.737		825.880	8.93%
12/24/2015	Thursday	29.77	38.178	44.710	10.493	11.438	56.148		685.510	8.19%
12/25/2015	Friday	27.44	32.320	37.571	9.002	9.798	47.369		658.370	7.19%
12/26/2015	Saturday	33.90	0.000	0.000	0.000	0.000	0.000		502.750	0.00%
1/10/2016	Sunday	1.40	0.020	0.025	0.013	0.017	0.042	354.859	632.280	
1/11/2016	Monday	19.02	0.000	0.000	0.000	0.000	0.000		806.750	
1/12/2016	Tuesday	5.38	0.000	0.000	0.000	0.000	0.000		835.800	
1/13/2016	Wednesday	25.81	0.000	0.000	0.000	0.000	0.000		795.290	
1/14/2016	Thursday	38.94	46.773	53.877	16.377	18.950	72.827		861.200	8.46%
1/15/2016	Friday	22.19	46.163	54.660	12.869	14.456	69.116		895.690	7.72%
1/16/2016	Saturday	10.12	0.000	0.000	0.000	0.000	0.000		586.800	0.00%
1/17/2016	Sunday	-2.58	0.000	0.000	0.000	0.000	0.000	320.761	664.360	0.00%
1/18/2016	Monday	4.32	34.620	40.280	9.498	10.342	50.622		773.410	6.55%
1/19/2016	Tuesday	10.15	42.345	49.885	11.537	12.722	62.607		996.080	6.29%
1/20/2016	Wednesday	15.47	43.628	51.499	12.067	13.361	64.860		1007.090	6.44%
1/21/2016	Thursday	18.36	50.660	59.923	14.943	16.923	76.846		1015.540	7.57%
1/22/2016	Friday	22.14	43.523	51.488	12.817	14.338	65.826		945.460	6.96%
1/23/2016	Saturday	21.78	0.000	0.000	0.000	0.000	0.000		569.310	0.00%
2/7/2016	Sunday	37.10	0.000	0.000	0.000	0.000	0.000	311.695	515.540	0.00%
2/8/2016	Monday	18.84	44.053	52.002	11.975	13.198	65.201		1057.180	6.17%
2/9/2016	Tuesday	13.87	43.575	51.359	12.013	13.315	64.674		1082.520	5.97%
2/10/2016	Wednesday	15.52	40.907	48.055	10.822	11.856	59.912		1046.320	5.73%
2/11/2016	Thursday	12.86	41.270	48.503	11.152	12.280	60.783		1065.510	5.70%

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
2/12/2016	Friday	15.37	41.662	49.032	10.993	12.093	61.125		1007.340	6.07%
2/13/2016	Saturday	8.63	0.000	0.000	0.000	0.000	0.000		605.480	0.00%
2/14/2016	Sunday	19.30	0.000	0.000	0.000	0.000	0.000	348.643	608.730	0.00%
2/15/2016	Monday	28.61	36.642	42.768	9.800	10.679	53.447		832.420	6.42%
2/16/2016	Tuesday	34.08	42.698	50.332	11.548	12.689	63.020		970.050	6.50%
2/17/2016	Wednesday	32.13	44.523	52.559	11.855	13.109	65.668		1017.770	6.45%
2/18/2016	Thursday	39.58	46.810	55.361	12.723	14.217	69.578		1011.190	6.88%
2/19/2016	Friday	51.14	65.708	75.655	18.275	21.274	96.929		948.970	10.21%
2/20/2016	Saturday	44.40	0.000	0.000	0.000	0.000	0.000		483.850	0.00%
3/6/2016	Sunday	50.76	0.000	0.000	0.000	0.000	0.000	771.351	474.380	0.00%
3/7/2016	Monday	61.92	91.687	104.514	27.188	31.317	135.831		1039.830	13.06%
3/8/2016	Tuesday	63.92	145.298	171.735	45.898	52.515	224.250		1065.630	21.04%
3/9/2016	Wednesday	45.16	117.487	136.604	33.300	38.766	175.370		1061.120	16.53%
3/10/2016	Thursday	44.26	105.867	125.053	31.382	35.867	160.920		1050.500	15.32%
3/11/2016	Friday	50.46	50.342	59.306	13.827	15.674	74.980		990.190	7.57%
3/12/2016	Saturday	47.72	0.000	0.000	0.000	0.000	0.000		442.000	0.00%
3/13/2016	Sunday	50.96	0.000	0.000	0.000	0.000	0.000	313.410	410.700	0.00%
3/14/2016	Monday	57.83	41.828	49.204	10.693	11.723	60.927		1043.550	5.84%
3/15/2016	Tuesday	55.32	41.653	48.991	10.535	11.538	60.530		1026.220	5.90%
3/16/2016	Wednesday	48.73	40.952	48.067	11.143	12.293	60.360		956.980	6.31%
3/17/2016	Thursday	45.64	46.705	54.819	12.382	13.865	68.684		984.680	6.98%
3/18/2016	Friday	36.59	42.515	50.261	11.430	12.649	62.910		859.630	7.32%
3/19/2016	Saturday	34.61	0.000	0.000	0.000	0.000	0.000		468.470	0.00%
4/3/2016	Sunday	59.91	0.000	0.000	0.000	0.000	0.000	559.994	425.760	0.00%
4/4/2016	Monday	43.94	101.390	116.175	29.880	34.587	150.762		955.580	15.78%
4/5/2016	Tuesday	41.84	50.782	60.131	13.753	15.430	75.562		940.000	8.04%
4/6/2016	Wednesday	45.82	74.090	85.490	21.018	24.580	110.070		937.010	11.75%
4/7/2016	Thursday	42.41	83.845	96.274	23.660	27.707	123.981		956.200	12.97%

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
4/8/2016	Friday	39.00	67.365	77.700	18.863	21.919	99.620		879.580	11.33%
4/9/2016	Saturday	36.18	0.000	0.000	0.000	0.000	0.000		445.140	0.00%
4/10/2016	Sunday	53.65	0.000	0.000	0.000	0.000	0.000	397.162	416.910	0.00%
4/11/2016	Monday	42.98	82.180	93.934	23.203	27.083	121.017		945.430	12.80%
4/12/2016	Tuesday	42.19	47.537	56.016	12.448	13.875	69.892		994.310	7.03%
4/13/2016	Wednesday	54.51	46.618	55.117	11.985	13.254	68.371		1038.770	6.58%
4/14/2016	Thursday	59.00	48.928	57.905	13.148	14.602	72.507		1041.690	6.96%
4/15/2016	Friday	62.83	44.430	52.610	11.513	12.765	65.375		986.210	6.63%
4/16/2016	Saturday	67.59	0.000	0.000	0.000	0.000	0.000		400.850	0.00%
5/1/2016	Sunday	46.15	0.000	0.000	0.000	0.000	0.000	360.030	456.830	0.00%
5/2/2016	Monday	51.34	49.328	58.279	13.362	14.951	73.230		1044.240	7.01%
5/3/2016	Tuesday	55.25	47.818	56.670	12.888	14.339	71.009		1080.230	6.57%
5/4/2016	Wednesday	58.26	50.253	59.592	14.080	15.805	75.397		1059.130	7.12%
5/5/2016	Thursday	55.48	50.170	59.436	13.453	15.046	74.482		1098.460	6.78%
5/6/2016	Friday	68.25	44.832	53.112	11.542	12.801	65.912		1091.220	6.04%
5/7/2016	Saturday	64.48	0.000	0.000	0.000	0.000	0.000		409.340	0.00%
5/8/2016	Sunday	61.86	0.000	0.000	0.000	0.000	0.000	344.363	405.570	0.00%
5/9/2016	Monday	59.89	46.588	55.121	12.238	13.548	68.669		1079.530	6.36%
5/10/2016	Tuesday	65.08	49.148	58.247	13.392	14.972	73.219		1172.620	6.24%
5/11/2016	Wednesday	60.34	48.182	57.110	12.742	14.159	71.269		1130.470	6.30%
5/12/2016	Thursday	56.41	45.372	53.604	11.843	13.072	66.675		1037.140	6.43%
5/13/2016	Friday	50.25	43.808	51.851	11.450	12.680	64.531		913.960	7.06%
5/14/2016	Saturday	47.49	0.000	0.000	0.000	0.000	0.000		424.760	0.00%
5/29/2016	Sunday	70.28	0.000	0.000	0.000	0.000	0.000	425.136	411.320	0.00%
5/30/2016	Monday	74.11	53.325	62.971	14.293	16.083	79.055		1043.300	7.58%
5/31/2016	Tuesday	69.26	59.458	70.343	16.500	18.873	89.215		1226.270	7.28%
6/1/2016	Wednesday	66.56	54.340	64.469	14.828	16.778	81.247		1189.200	6.83%
6/2/2016	Thursday	67.42	57.388	68.031	15.860	18.052	86.083		1246.800	6.90%

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
6/3/2016	Friday	74.59	49.673	58.969	13.557	15.295	74.263		1091.930	6.80%
6/4/2016	Saturday	69.47	10.332	11.866	2.900	3.407	15.273		531.780	2.87%
6/5/2016	Sunday	72.66	0.000	0.000	0.000	0.000	0.000	493.617	431.670	0.00%
6/6/2016	Monday	69.49	70.235	82.414	19.588	22.762	105.175		1292.250	8.14%
6/7/2016	Tuesday	67.77	56.145	66.638	15.472	17.584	84.222		1178.180	7.15%
6/8/2016	Wednesday	73.18	59.905	70.961	16.493	18.883	89.844		1244.940	7.22%
6/9/2016	Thursday	82.17	67.397	79.380	20.117	23.367	102.748		1366.860	7.52%
6/10/2016	Friday	84.07	74.087	87.021	21.127	24.607	111.628		1470.350	7.59%
6/11/2016	Saturday	78.32	0.000	0.000	0.000	0.000	0.000		439.440	0.00%
6/26/2016	Sunday	80.17	0.000	0.000	0.000	0.000	0.000	524.059	430.160	0.00%
6/27/2016	Monday	80.20	94.238	108.859	26.180	30.822	139.681		1466.710	9.52%
6/28/2016	Tuesday	75.10	74.868	87.560	20.793	24.320	111.880		1316.620	8.50%
6/29/2016	Wednesday	71.02	62.900	74.332	17.710	20.398	94.730		1237.390	7.66%
6/30/2016	Thursday	73.59	65.472	77.124	18.673	21.614	98.738		1282.930	7.70%
7/1/2016	Friday	69.89	52.310	62.076	14.913	16.953	79.029		1096.760	7.21%
7/2/2016	Saturday	65.27	0.000	0.000	0.000	0.000	0.000		416.170	0.00%
7/3/2016	Sunday	66.55	0.000	0.000	0.000	0.000	0.000	504.103	416.280	0.00%
7/4/2016	Monday	63.72	52.295	61.620	13.862	15.552	77.172		1005.460	7.68%
7/5/2016	Tuesday	79.39	68.253	80.266	19.258	22.409	102.675		1376.390	7.46%
7/6/2016	Wednesday	81.17	79.777	92.735	22.478	26.453	119.188		1488.840	8.01%
7/7/2016	Thursday	72.26	72.552	84.918	20.432	23.839	108.757		1405.170	7.74%
7/8/2016	Friday	78.90	64.168	75.440	17.958	20.872	96.311		1266.180	7.61%
7/9/2016	Saturday	76.93	0.000	0.000	0.000	0.000	0.000		430.600	0.00%
7/24/2016	Sunday	83.59	0.000	0.000	0.000	0.000	0.000	556.792		
7/25/2016	Monday	80.03	94.132	108.634	26.260	30.934	139.568			
7/26/2016	Tuesday	78.96	80.828	94.040	22.752	26.762	120.802			
7/27/2016	Wednesday	78.23	72.857	85.303	20.680	24.159	109.462			
7/28/2016	Thursday	75.80	72.180	84.505	20.442	23.867	108.372			

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
7/29/2016	Friday	69.10	52.435	61.912	14.658	16.677	78.589			
7/30/2016	Saturday	71.75	0.000	0.000	0.000	0.000	0.000			
7/31/2016	Sunday	76.99	0.000	0.000	0.000	0.000	0.000	542.143		
8/1/2016	Monday	71.84	79.042	92.270	22.402	26.103	118.373			
8/2/2016	Tuesday	71.20	66.802	78.591	18.983	22.006	100.597			
8/3/2016	Wednesday	75.79	75.017	87.688	21.273	24.926	112.614			
8/4/2016	Thursday	84.73	81.835	95.214	23.373	27.443	122.656			
8/5/2016	Friday	75.92	58.150	68.684	16.713	19.219	87.903			
8/6/2016	Saturday	74.07	0.000	0.000	0.000	0.000	0.000			
8/21/2016	Sunday	67.93	0.000	0.000	0.000	0.000	0.000	486.985		
8/22/2016	Monday	71.16	78.613	91.589	23.480	27.490	119.078			
8/23/2016	Tuesday	74.12	67.072	78.810	19.173	22.261	101.071		1282.300	7.88%
8/24/2016	Wednesday	75.30	69.400	81.377	19.865	23.132	104.509		1348.010	7.75%
8/25/2016	Thursday	71.47	60.118	70.995	17.233	19.759	90.754		1245.470	7.29%
8/26/2016	Friday	67.81	47.752	56.552	13.368	15.021	71.573		1066.270	6.71%
8/27/2016	Saturday	66.30	0.000	0.000	0.000	0.000	0.000		407.670	0.00%
8/28/2016	Sunday	77.59	12.470	14.405	3.558	4.158	18.563	504.802	556.956	3.33%
8/29/2016	Monday	75.82	79.054	92.349	22.290	26.034	118.383		1443.302	8.20%
8/30/2016	Tuesday	75.30	68.417	80.414	19.280	22.382	102.796		1355.305	7.58%
8/31/2016	Wednesday	73.97	66.157	77.825	18.730	21.698	99.523		1327.259	7.50%
9/1/2016	Thursday	70.34	61.648	72.767	17.535	20.157	92.925		1229.015	7.56%
9/2/2016	Friday	68.12	48.513	57.611	13.350	15.002	72.613		1037.209	7.00%
9/3/2016	Saturday	68.84	0.000	0.000	0.000	0.000	0.000		407.250	0.00%
9/18/2016	Sunday	70.57	0.000	0.000	0.000	0.000	0.000	526.414	395.181	0.00%
9/19/2016	Monday	75.15	80.867	94.354	23.092	27.013	121.367		1367.154	8.88%
9/20/2016	Tuesday	75.48	66.130	77.843	18.927	21.944	99.787		1316.510	7.58%
9/21/2016	Wednesday	82.71	74.985	87.459	21.892	25.618	113.077		1475.053	7.67%
9/22/2016	Thursday	76.82	65.273	76.914	18.932	21.874	98.788		1328.821	7.43%

Fixed Static Pressure										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Exhaust Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
9/23/2016	Friday	77.17	61.863	72.809	17.763	20.585	93.394		1242.057	7.52%
9/24/2016	Saturday	77.20	0.000	0.000	0.000	0.000	0.000		406.870	0.00%
9/25/2016	Sunday	68.37	18.220	21.241	5.115	5.910	27.151	539.187	592.560	4.58%
9/26/2016	Monday	61.83	64.053	74.571	18.935	21.824	96.395		1075.508	8.96%
9/27/2016	Tuesday	62.92	64.117	75.696	18.603	21.274	96.970		1159.082	
9/28/2016	Wednesday	57.00	85.485	100.191	24.820	28.400	128.591		1037.235	
9/29/2016	Thursday	62.60	57.860	68.315	16.422	18.764	87.078		1079.515	
9/30/2016	Friday	61.00	55.202	64.335	15.285	17.494	81.829			
10/1/2016	Saturday	61.97	14.477	16.969	3.823	4.202	21.171			

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Site #5:

TTR Method										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Return Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
7/12/2015	Sunday							433.988		
7/13/2015	Monday									
7/14/2015	Tuesday									
7/15/2015	Wednesday									
7/16/2015	Thursday	76.26	44.977	53.006	23.953	28.285	81.291			
7/17/2015	Friday	83.36	49.158	57.886	25.077	29.560	87.446			
7/18/2015	Saturday	82.12	2.483	3.104	2.375	2.968	6.072			
7/19/2015	Sunday	75.61	2.432	3.040	2.383	2.979	6.019	413.971		
7/20/2015	Monday	74.30	58.252	68.519	28.227	33.292	101.812			
7/21/2015	Tuesday	69.70	42.082	49.321	20.755	24.381	73.702			
7/22/2015	Wednesday	68.23	41.310	48.301	20.852	24.447	72.748			
7/23/2015	Thursday	72.69	38.510	45.036	19.092	22.384	67.421			
7/24/2015	Friday	77.13	48.202	56.814	24.880	29.374	86.187			
7/25/2015	Saturday	80.65	2.470	3.087	2.397	2.996	6.083			
7/26/2015	Sunday	77.51	2.480	3.100	2.385	2.981	6.081	628.451		
7/27/2015	Monday	74.11	104.715	124.124	47.462	56.526	180.649			
7/28/2015	Tuesday	74.39	66.895	77.297	32.645	37.732	115.030			
7/29/2015	Wednesday	75.99	42.258	49.394	21.080	24.700	74.094			
7/30/2015	Thursday									
7/31/2015	Friday									
8/1/2015	Saturday									
9/6/2015	Sunday	81.87	5.065	6.107	3.160	3.818	9.925	342.046	760.780	1.30%
9/7/2015	Monday	76.74	35.765	41.159	17.295	19.984	61.143		1031.460	5.93%
9/8/2015	Tuesday	73.98	41.593	48.791	20.973	24.711	73.502		1180.730	6.23%
9/9/2015	Wednesday	69.34	36.465	42.446	18.125	21.201	63.647		1116.970	5.70%
9/10/2015	Thursday	71.52	42.965	50.452	21.612	25.471	75.923		1217.820	6.23%

TTR Method										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Return Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
9/11/2015	Friday	59.66	25.758	29.135	13.128	14.880	44.015			
9/12/2015	Saturday	56.46	8.053	9.548	3.378	4.344	13.891			
9/13/2015	Sunday	59.99	8.412	9.742	3.557	4.446	14.187	251.104		
9/14/2015	Monday	70.26	28.032	32.112	7.065	8.064	40.175			
9/15/2015	Tuesday	74.34	30.017	34.416	7.968	9.094	43.510			
9/16/2015	Wednesday	75.30	31.802	36.658	8.248	9.346	46.004			
9/17/2015	Thursday	76.49	36.970	42.745	9.658	11.009	53.754			
9/18/2015	Friday		27.012	30.870	7.018	8.150	39.020			
9/19/2015	Saturday	57.43	3.613	4.515	2.480	3.098	7.613			
10/4/2015	Sunday	48.28	3.615	3.615	2.467	2.467	6.082	203.507	534.924	1.14%
10/5/2015	Monday								1038.652	
10/6/2015	Tuesday	59.89	26.622	30.333	6.965	7.935	38.269		1054.889	3.63%
10/7/2015	Wednesday								1075.958	
10/8/2015	Thursday								1129.293	
10/9/2015	Friday								947.465	
10/10/2015	Saturday								566.583	
10/11/2015	Sunday								591.521	
10/12/2015	Monday								885.051	
10/13/2015	Tuesday								992.276	
10/14/2015	Wednesday								1001.705	
10/15/2015	Thursday								1071.710	
10/16/2015	Friday								867.830	
10/17/2015	Saturday								571.22	
11/1/2015	Sunday									
11/2/2015	Monday									
11/3/2015	Tuesday									
11/4/2015	Wednesday									
11/5/2015	Thursday									

TTR Method										
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Return Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
11/6/2015	Friday									
11/7/2015	Saturday									
11/8/2015	Sunday									
11/9/2015	Monday									
11/10/2015	Tuesday									
11/11/2015	Wednesday									
11/12/2015	Thursday									
11/13/2015	Friday									
11/14/2015	Saturday									
11/29/2015	Sunday									
11/30/2015	Monday									
12/1/2015	Tuesday									
12/2/2015	Wednesday									
12/3/2015	Thursday									
12/4/2015	Friday									
12/5/2015	Saturday									
12/6/2015	Sunday									
12/7/2015	Monday									
12/8/2015	Tuesday									
12/9/2015	Wednesday									
12/10/2015	Thursday									
12/11/2015	Friday									
12/12/2015	Saturday									
12/27/2015	Sunday	25.13	0.000	0.000	0.000	0.000	0.000	133.218	562.760	0.00%
12/28/2015	Monday	25.13	17.565	19.559	5.575	6.563	26.122		845.700	3.09%
12/29/2015	Tuesday	23.68	26.345	29.915	6.480	7.314	37.229		884.610	4.21%
12/30/2015	Wednesday	25.26	22.298	25.122	5.345	6.177	31.299		842.740	3.71%
12/31/2015	Thursday	21.17	14.458	16.008	3.248	4.059	20.067		794.610	2.53%

TTR Method										
Date		Average Daily Temp.	AHU-1 Supply Fan		AHU-1 Return Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
1/1/2016	Friday	26.68	13.240	14.669	3.067	3.832	18.501		695.170	2.66%
1/2/2016	Saturday	23.99	0.000	0.000	0.000	0.000	0.000		526.920	0.00%
1/3/2016	Sunday	23.81	0.000	0.000	0.000	0.000	0.000	203.930	578.690	0.00%
1/4/2016	Monday	24.32	16.772	18.445	3.747	4.660	23.105		909.200	2.54%
1/5/2016	Tuesday	26.08	20.037	22.414	4.715	5.587	28.001		928.360	3.02%
1/6/2016	Wednesday	31.06	27.423	31.493	6.830	7.745	39.238		945.160	4.15%
1/7/2016	Thursday	34.36	39.285	46.198	10.803	12.201	58.399		937.830	6.23%
1/8/2016	Friday	33.17	37.338	43.865	9.638	11.322	55.188		843.790	6.54%
1/9/2016	Saturday	10.45	0.000	0.000	0.000	0.000	0.000		595.700	0.00%
1/24/2016	Sunday	28.78	0.000	0.000	0.000	0.000	0.000	309.946	542.000	0.00%
1/25/2016	Monday	27.31	41.863	49.156	10.827	11.936	61.092		1029.470	5.93%
1/26/2016	Tuesday	28.37	40.637	47.536	9.977	10.961	58.497		1002.450	5.84%
1/27/2016	Wednesday	32.05	41.490	48.624	10.582	11.649	60.273		1026.920	5.87%
1/28/2016	Thursday	33.57	50.790	59.894	13.392	15.117	75.011		1031.380	7.27%
1/29/2016	Friday	33.44	38.252	44.796	9.398	10.279	55.074		926.420	5.94%
1/30/2016	Saturday	39.02	0.000	0.000	0.000	0.000	0.000		495.000	0.00%
1/31/2016	Sunday	37.37	0.000	0.000	0.000	0.000	0.000	233.487	500.890	0.00%
2/1/2016	Monday	34.61	49.922	58.873	13.348	15.004	73.877		988.350	7.47%
2/2/2016	Tuesday	33.70	19.303	21.451	4.637	5.504	26.955		740.870	3.64%
2/3/2016	Wednesday	22.67	25.333	28.501	6.188	7.056	35.556		930.740	3.82%
2/4/2016	Thursday	22.54	30.543	35.145	7.390	8.294	43.440		1018.420	4.27%
2/5/2016	Friday	22.47	37.240	43.461	9.297	10.198	53.659		1011.930	5.30%
2/6/2016	Saturday	32.91	0.000	0.000	0.000	0.000	0.000		513.320	0.00%
2/21/2016	Sunday	36.03	2.847	3.177	0.615	0.715	3.892	269.319	521.920	0.75%
2/22/2016	Monday	36.04	40.295	46.976	9.770	10.865	57.841		966.930	5.98%
2/23/2016	Tuesday	37.15	35.480	40.948	8.665	9.545	50.493		939.870	5.37%
2/24/2016	Wednesday	34.84	35.710	41.251	8.993	9.940	51.191		960.230	5.33%
2/25/2016	Thursday	31.04	34.543	39.786	9.002	9.989	49.775		997.410	4.99%

TTR Method											
Date		**Average Daily Temp.**	**AHU-1 Supply Fan**		**AHU-1 Return Fan**		**Fan - Total**		**Building Use**	**Fan vs Building**
mm/dd/yy	**day**	**Deg F**	**(Raw)**	**(Corrected)**	**(Raw)**	**(Corrected)**	**(Corrected)**	**Corrected nominal weekly**		
			kWh		**kWh**		**kWh**	**kWh**	**kWh**	**%**
2/26/2016	Friday	36.44	39.373	45.644	9.480	10.483	56.127		981.340	5.72%
2/27/2016	Saturday	49.90	0.000	0.000	0.000	0.000	0.000		491.490	0.00%
2/28/2016	Sunday	48.45	0.000	0.000	0.000	0.000	0.000	236.319	502.550	0.00%
2/29/2016	Monday	38.62	45.707	53.283	12.752	14.527	67.809		988.930	6.86%
3/1/2016	Tuesday	23.05	32.603	37.383	8.513	9.464	46.848		980.000	4.78%
3/2/2016	Wednesday	25.52	26.450	30.124	6.353	7.198	37.322		1010.770	3.69%
3/3/2016	Thursday	31.49	32.767	37.597	7.828	8.692	46.289		959.450	4.82%
3/4/2016	Friday	37.50	26.923	30.711	6.550	7.340	38.052		837.870	4.54%
3/5/2016	Saturday	35.39	0.000	0.000	0.000	0.000	0.000		498.480	0.00%
3/20/2016	Sunday	37.32	0.000	0.000	0.000	0.000	0.000	258.142	486.890	0.00%
3/21/2016	Monday	43.10	36.912	43.118	10.273	11.537	54.655		1044.420	5.23%
3/22/2016	Tuesday	54.69	28.567	32.635	6.750	7.599	40.234		1038.530	3.87%
3/23/2016	Wednesday	43.74	50.923	59.952	13.620	15.409	75.361		951.400	7.92%
3/24/2016	Thursday	33.50	33.040	38.082	9.953	11.023	49.105		955.940	5.14%
3/25/2016	Friday	39.66	26.448	30.296	7.415	8.491	38.788		929.590	4.17%
3/26/2016	Saturday	44.78	0.000	0.000	0.000	0.000	0.000		467.510	0.00%
3/27/2016	Sunday	40.06	0.000	0.000	0.000	0.000	0.000	309.219	469.450	0.00%
3/28/2016	Monday	49.77	41.697	49.015	11.042	12.117	61.132		1052.430	5.81%
3/29/2016	Tuesday	52.48	30.742	35.226	7.317	8.154	43.380		1019.700	4.25%
3/30/2016	Wednesday	58.80	27.960	31.859	7.515	8.456	40.315		1059.670	3.80%
3/31/2016	Thursday	47.92	62.565	72.698	17.435	20.130	92.828		996.050	9.32%
4/1/2016	Friday	40.97	48.307	56.808	13.025	14.756	71.564		849.150	8.43%
4/2/2016	Saturday	39.88	0.000	0.000	0.000	0.000	0.000		460.190	0.00%
4/17/2016	Sunday	67.52	0.000	0.000	0.000	0.000	0.000	369.169	401.960	0.00%
4/18/2016	Monday	65.72	51.268	60.815	13.890	15.589	76.405		1144.330	6.68%
4/19/2016	Tuesday	54.51	56.993	66.832	15.827	18.073	84.905		1010.050	8.41%
4/20/2016	Wednesday	55.15	47.238	55.645	12.843	14.391	70.036		1022.200	6.85%
4/21/2016	Thursday	55.35	48.115	56.855	12.892	14.418	71.273		1054.020	6.76%

TTR Method										
Date		Average Daily Temp.	AHU-1 Supply Fan		AHU-1 Return Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
4/22/2016	Friday	54.06	45.173	52.411	12.303	14.139	66.550		938.970	7.09%
4/23/2016	Saturday	57.35	0.000	0.000	0.000	0.000	0.000		422.420	0.00%
4/24/2016	Sunday	67.75	0.000	0.000	0.000	0.000	0.000	530.010	410.490	0.00%
4/25/2016	Monday	65.01	49.055	57.952	12.588	14.026	71.978		1156.240	6.23%
4/26/2016	Tuesday	57.81	64.112	74.822	18.193	20.950	95.772		1051.860	9.11%
4/27/2016	Wednesday	48.20	92.387	105.127	25.918	30.534	135.662		977.970	13.87%
4/28/2016	Thursday	49.80	67.418	78.430	18.597	21.476	99.905		1029.500	9.70%
4/29/2016	Friday	47.46	85.978	98.186	24.227	28.506	126.692		904.180	14.01%
4/30/2016	Saturday	46.48	0.000	0.000	0.000	0.000	0.000		457.390	0.00%
5/15/2016	Sunday	52.84	0.000	0.000	0.000	0.000	0.000	274.631	416.360	0.00%
5/16/2016	Monday	54.54	36.045	41.815	8.987	10.077	51.891		1035.990	5.01%
5/17/2016	Tuesday	52.81	41.652	48.625	9.972	11.080	59.705		1056.570	5.65%
5/18/2016	Wednesday	55.05	39.812	46.380	9.600	10.642	57.022		1071.890	5.32%
5/19/2016	Thursday	58.72	42.623	49.835	10.515	11.664	61.499		1091.700	5.63%
5/20/2016	Friday	60.62	31.582	36.184	7.427	8.330	44.514		1032.620	4.31%
5/21/2016	Saturday	61.21	0.000	0.000	0.000	0.000	0.000		403.120	0.00%
5/22/2016	Sunday	65.39	0.000	0.000	0.000	0.000	0.000	357.607	404.090	0.00%
5/23/2016	Monday	68.30	53.862	63.881	15.150	17.135	81.016		1207.820	6.71%
5/24/2016	Tuesday	70.94	58.852	69.803	16.482	18.857	88.660		1267.530	6.99%
5/25/2016	Wednesday	70.99	48.175	56.782	12.548	14.080	70.862		1211.850	5.85%
5/26/2016	Thursday	68.94	48.647	57.326	13.105	14.868	72.194		1204.260	5.99%
5/27/2016	Friday	67.14	26.922	30.357	6.165	7.069	37.426		944.570	3.96%
5/28/2016	Saturday	67.06	5.108	5.947	1.318	1.502	7.448		475.580	1.57%
6/12/2016	Sunday	84.67	0.000	0.000	0.000	0.000	0.000	526.844	444.620	0.00%
6/13/2016	Monday	82.23	93.522	107.661	24.885	29.191	136.852		1570.780	8.71%
6/14/2016	Tuesday	81.61	73.143	85.052	19.708	23.038	108.090		1480.020	7.30%
6/15/2016	Wednesday	83.45	68.760	80.781	18.418	21.366	102.147		1468.920	6.95%
6/16/2016	Thursday	79.83	65.238	76.891	17.407	20.039	96.930		1411.490	6.87%

TTR Method										
Date		Average Daily Temp.	AHU-1 Supply Fan		AHU-1 Return Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
6/17/2016	Friday	78.98	56.013	66.223	14.635	16.603	82.826		1250.230	6.62%
6/18/2016	Saturday	80.79	0.000	0.000	0.000	0.000	0.000		424.660	0.00%
6/19/2016	Sunday	80.72	0.000	0.000	0.000	0.000	0.000	507.089	422.190	0.00%
6/20/2016	Monday	81.20	88.783	102.539	23.918	28.019	130.557		1474.300	8.86%
6/21/2016	Tuesday	78.46	70.010	82.136	18.653	21.641	103.777		1365.470	7.60%
6/22/2016	Wednesday	81.65	66.895	78.793	17.798	20.556	99.350		1458.310	6.81%
6/23/2016	Thursday	76.51	63.222	74.521	16.700	19.148	93.669		1350.030	6.94%
6/24/2016	Friday	76.28	53.985	63.949	13.982	15.788	79.736		1255.680	6.35%
6/25/2016	Saturday	84.08	0.000	0.000	0.000	0.000	0.000		421.700	0.00%
7/10/2016	Sunday	76.11	0.000	0.000	0.000	0.000	0.000	489.654	430.280	0.00%
7/11/2016	Monday	84.70	85.700	99.467	23.343	27.387	126.854		1563.690	8.11%
7/12/2016	Tuesday	75.71	66.235	78.059	17.998	20.782	98.841		1347.990	7.33%
7/13/2016	Wednesday	76.56	65.455	76.932	17.733	20.483	97.415			
7/14/2016	Thursday	78.18	64.380	75.867	17.237	19.867	95.735			
7/15/2016	Friday	69.73	48.208	56.843	12.440	13.967	70.810			
7/16/2016	Saturday	74.30	0.000	0.000	0.000	0.000	0.000			
7/17/2016	Sunday	75.63	0.000	0.000	0.000	0.000	0.000	483.133		
7/18/2016	Monday	76.76	80.347	93.972	22.005	25.686	119.658			
7/19/2016	Tuesday	72.66	57.322	67.337	15.553	17.845	85.182			
7/20/2016	Wednesday	82.94	65.143	76.705	17.795	20.545	97.250			
7/21/2016	Thursday	87.62	72.217	84.869	19.697	22.883	107.752			
7/22/2016	Friday	84.07	50.075	58.982	12.743	14.309	73.291			
7/23/2016	Saturday	85.23	0.000	0.000	0.000	0.000	0.000			
8/7/2016	Sunday	73.31	0.000	0.000	0.000	0.000	0.000	572.129		
8/8/2016	Monday	74.03	71.833	84.104	19.693	22.848	106.952			
8/9/2016	Tuesday	79.35	72.988	85.269	19.915	23.251	108.520			
8/10/2016	Wednesday	81.57	90.007	105.915	25.345	29.372	135.287			
8/11/2016	Thursday	80.16	93.993	110.790	27.113	31.242	142.032			

TTR Method											
Date		Average Daily Temp.	AHU-1 Supply Fan		AHU-1 Return Fan		Fan - Total		Building Use	Fan vs Building
mm/dd/yy	day	Deg F	(Raw)	(Corrected)	(Raw)	(Corrected)	(Corrected)	Corrected nominal weekly		
			kWh		kWh		kWh	kWh	kWh	%
8/12/2016	Friday	73.87	53.470	63.010	14.333	16.329	79.339			
8/13/2016	Saturday	76.77	0.000	0.000	0.000	0.000	0.000			
8/14/2016	Sunday	76.78	0.000	0.000	0.000	0.000	0.000	535.893		
8/15/2016	Monday	75.76	88.737	103.164	24.710	28.783	131.948			
8/16/2016	Tuesday	76.89	67.375	78.951	18.052	20.932	99.883			
8/17/2016	Wednesday	78.81	68.757	80.837	18.687	21.656	102.493			
8/18/2016	Thursday	81.94	69.098	81.251	18.735	21.674	102.925			
8/19/2016	Friday	79.82	59.118	69.422	15.630	17.955	87.377			
8/20/2016	Saturday	68.20	7.652	8.896	2.050	2.371	11.267			
9/4/2016	Sunday	71.12	0.000	0.000	0.000	0.000	0.000	450.038	409.823	0.00%
9/5/2016	Monday	78.69	48.222	56.263	13.780	15.507	71.771		1086.345	6.61%
9/6/2016	Tuesday	83.51	67.580	79.212	21.607	25.150	104.362		1474.137	7.08%
9/7/2016	Wednesday	76.83	59.102	69.222	16.687	19.308	88.529		1297.454	6.82%
9/8/2016	Thursday	74.00	62.648	73.849	17.173	19.775	93.623		1335.706	7.01%
9/9/2016	Friday	75.47	53.230	62.478	14.602	16.794	79.271		1177.338	6.73%
9/10/2016	Saturday	65.47	8.705	9.970	2.182	2.511	12.481		520.756	2.40%
9/11/2016	Sunday	66.07	0.000	0.000	0.000	0.000	0.000	381.132		
9/12/2016	Monday	71.71	58.272	68.439	17.083	19.699	88.138			
9/13/2016	Tuesday	68.26	51.248	60.320	14.010	15.944	76.264			
9/14/2016	Wednesday	65.72	44.187	51.792	11.177	12.495	64.287			
9/15/2016	Thursday	73.50	53.478	62.959	14.623	16.622	79.581			
9/16/2016	Friday	64.30	40.153	46.863	9.718	10.880	57.743			
9/17/2016	Saturday	68.32	10.363	12.078	2.695	3.041	15.118			

APPENDIX G VFD POWER CORRECTION TABLE

Site #1:

AHU-2 SF		Input		Output
Speed	Frequency	Power Meter	Data Logger	VFD Display
%	Hz	kW	kW	kW
30.00%	18	0.465	0.519	0.41
45.00%	27	1.33	1.38	1.3
60.00%	36	2.6	2.77	2.65
75.00%	45	3.85	3.98	3.8
90.00%	54.2	5.95	5.54	5.9
100.00%	60	-	-	-

AHU-1 SF		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.75	0.6
50.00%	30	2.2	2
66.67%	40	3.8	3.2
83.33%	50	6.4	5.6
100.00%	60	9.7	8.1

AHU-3 SF		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.77	0.6
50.00%	30	2.2	2
66.67%	40	4.6	3.9
83.33%	50	7.7	6.4
100.00%	60	10.2	8.8

AHU-4 SF		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.75	0.6
50.00%	30	2.2	2
66.67%	40	4.6	3.9
83.33%	50	7.5	6.1
100.00%	60	-	-

AHU-9 SF		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.19	0.1
50.00%	30	0.37	0.3
66.67%	40	0.64	0.5
83.33%	50	1.01	0.8
100.00%	60	1.58	1.3

AHU-12 ES 1 & 2		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	1.7	2.3
50.00%	30	2.7	3.55
66.67%	40	12.3	13.3
83.33%	50	22.7	23.15
100.00%	60	-	-

AHU-12 ES 3 & 4		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	1.5	2.2
50.00%	30	2.6	3.4
66.67%	40	12.2	13.25
83.33%	50	22.4	23.2
100.00%	60	-	-

AHU-12 ER 1 & 2		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.49	0.4
50.00%	30	1.38	1.1
66.67%	40	2.9	2.5
83.33%	50	5.4	4.7
100.00%	60	8.8	7.8

AHU-12 ER 3 & 4		Input	Output
Speed	Frequency	Power Meter	VFD Display
%	Hz	kW	kW
16.67%	10	-	-
33.33%	20	0.56	0.4
50.00%	30	1.53	1.3
66.67%	40	3.2	2.8
83.33%	50	6	5.2
100.00%	60	-	-

Site #2:

AHU-1 SF		Input	Output
VFD Speed	**VFD Frequency**	**Power Meter**	**VFD Display**
%	**Hz**	**kW**	**kW**
16.67%	10	-	-
33.33%	20	0.41	0.37
50.00%	30	1.11	1
66.67%	40	2.38	2.25
83.33%	50	4.4	4.1
100.00%	60	6.9	6.7

AHU-1 RF		Input	Output
VFD Speed	**VFD Frequency**	**Power Meter**	**VFD Display**
%	**Hz**	**kW**	**kW**
16.67%	10	-	-
33.33%	20	0.57	0.488
50.00%	30	1.2	1.14
66.67%	40	2.3	2.32
83.33%	50	4.3	4.21
100.00%	60	6.95	6.87

AHU-2 SF		Input	Output
VFD Speed	**VFD Frequency**	**Power Meter**	**VFD Display**
%	**Hz**	**kW**	**kW**
16.67%	10	-	-
33.33%	20	0.53	0.36
50.00%	30	1.09	0.865
66.67%	40	2.3	2.1
83.33%	50	4.5	4
100.00%	60	7.45	6.7

AHU-2 RF		Input	Output
VFD Speed	**VFD Frequency**	**Power Meter**	**VFD Display**
%	**Hz**	**kW**	**kW**
16.67%	10	-	-
33.33%	20	0.43	0.35
50.00%	30	0.68	0.59
66.67%	40	1.515	1.39
83.33%	50	2.8	2.75
100.00%	60	4.8	4.72